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TREÅRSEXPEDITIONEN TIL CHRISTIAN DEN X'S LAND 1931-34

UNDER LEDELSE AF LAUGE KOCH

ON THE PLACODERMI OF THE
UPPER DEVONIAN OF EAST GREENLAND

SUPPLEMENT TO PART I

BY

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WITH 26 FIGURES IN THE TEXT AND 30 PLATES

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

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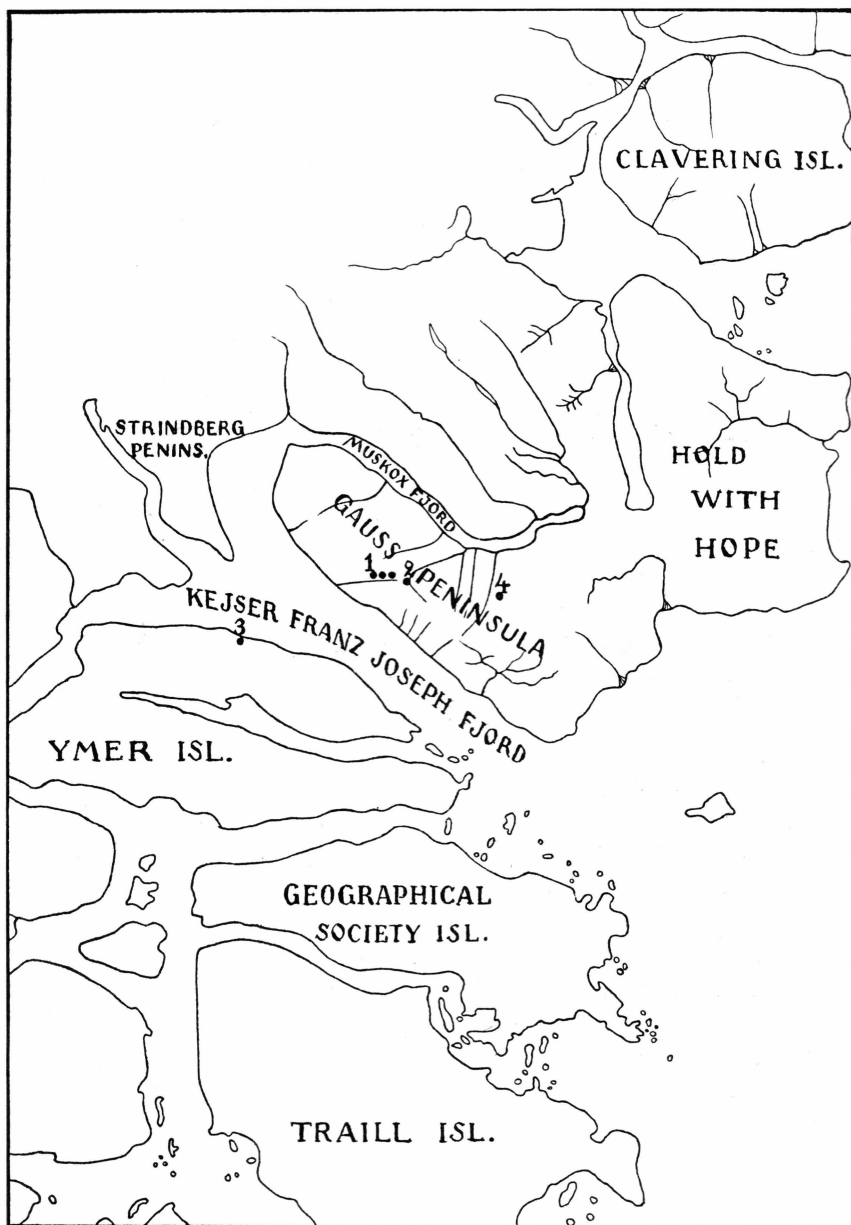
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INTRODUCTION

During the Danish summer expedition to East Greenland in 1934 under Dr. LAUGE KOCH's leadership a large, new material of fossil vertebrates was brought together in the Upper Devonian deposits on Gaus Peninsula and along the north coast of Ymer Island. The position of the various localities in which collecting was made is shown in the sketch map in text-fig. 1. A detailed description of certain of these localities was recently given by JOHANSSON (1935). The other ones will be described by SÄVE-SÖDERBERGH (1936).

The new Upper Devonian material from the summer expedition in 1934 comprises Placoderms, Crossopterygians and Stegocephalians, but no Dipnoans and no representatives of the new group of lower *Choanata* of which remains were found during two earlier expeditions (STENSIÖ 1934 a, p. 5; SÄVE-SÖDERBERGH 1934 a, b). The Placoderms do not show any new groups or new genera, but in spite of that they are of much interest as they are so well preserved as to give many new contributions to our knowledge of the group as a whole. Particularly this is the case with *Phyllolepis*, of which several specimens have been found which show most of the plates of the armour in their natural position in relation to each other. The Crossopterygians too are better preserved than those found earlier in the East Greenland Devonian. Among others it should be mentioned that a few of the new *Holopthychius* specimens have the skull so well preserved that considerable parts both of its exoskeleton and endoskeleton may be studied in detail. In a near future we shall therefore gain a fairly complete knowledge of the cranial anatomy of the Holoptychiids. Finally the Stegocephalians are both more numerous and better preserved than those found during any of the preceding expeditions. Above all it is of importance that among the new Stegocephalian material there are specimens which show the endocranium and parts of the vertebral column and limb girdles. It is even possible that one or two of the specimens may have parts of the limbs preserved.



Text-fig. 1. Sketch map showing the position of the localities at which *Phyllolepis* and *Euarthrodire* remains were collected during the summer 1934. Scale 1:1500 000. 1, the localities on Mt. Sederholm; 2, the locality in the mouth of the Glacier Valley; 3, the locality on Bothriolepis Mtn.; 4, the locality on Mt. La Cour (*Euarthrodires*).

The present paper deals with the new Placoderm material, mainly with the *Phyllolepis* remains, and it is therefore properly published as a supplement to Part I of my monograph "On the Placodermi of the Upper Devonian of East Greenland".

For the opportunity of describing the new Placoderm material under consideration I am highly indebted to Dr. LAUGE KOCH. In this connection I also wish to express my deepest gratitude to Dr. KOCH for much support during my work with the material and for a very pleasant collaboration throughout. I have to thank Dr. G. SÄVE-SÖDERBERGH for important information concerning *Phyllolepis concentrica*, which he studied in detail during a recent visit to the British Museum and the Royal Scottish Museum, and for information concerning the find localities around the Franz Joseph Fjord. Finally I also want to thank here Fil. mag. E. JOHANSSON and Fil. mag. G. WÄNGSJÖ, who have collected the bulk of the material dealt with here and who have given me important information concerning the find localities in and around Parallel Valley.

For the loan of material for comparison of *Phyllolepis concentrica* I am highly indebted to Dr. ERROL J. WHITE, British Museum, and to the authorities of the Royal Scottish Museum in Edinburgh.

Remarks on the stratigraphical occurrence of *Phyllolepis* and *Euarthrodires* in East Greenland.

Phyllolepis occurs abundantly in the *Phyllolepis* series (cf. SÄVE-SÖDERBERGH 1934a, pp. 47—48; STENSIÖ 1934a, p. 9; JOHANSSON 1935, pp. 28—32), but seems to be absent both in the *Remigolepis* series and the Arthrodire sandstone series.

The fauna of the *Phyllolepis* series is not very rich in forms, apart from *Phyllolepis*, containing only *Holoptychius*, *Bothriolepis* and *Onychodus* Pl. 16, figs. 1, 2). However, *Onychodus* is very rare, only a single specimen of it being found as yet. As is well known, all these forms have a wide horizontal distribution. *Phyllolepis*, *Holoptychius* and *Bothriolepis* are all confined to the Upper Devonian (cf. STENSIÖ 1934 a, pp. 12—13), whereas *Onychodus* is known both from the Middle and Upper Devonian¹⁾

Euarthrodires are at present known with certainty only from the Arthrodire sandstone series, in which, however, they are rare. Besides *Euarthrodires* this series has as yet yielded only Crossopterygians which at least in the main seem to be *Holoptychiids*.

Genus *Phyllolepis*.

General remarks.

General shape and mode of living.

In all those cases in which it has been found somewhat completely preserved the armour is much compressed in a dorsi-ventral direction. In fact it is even so flat that there is little space left between its dorsal and ventral walls (pls. 24—28). Also originally, before the embedding in the rock, it must obviously have been low. In *Ph. orvini*, which at present is the species which is best known in regard to its proportions, the trunk armour seems even to have been so low, that its maximum

¹⁾ Certain of the specimens figured and described by EASTMAN as *Onychodus* seem not to belong to that genus or may at least be placed in it with much doubt (cf. EASTMAN 1907; pl. 1, figs. 3, 4, 14, and pl. 9, figs. 1, 2).

height was only about one fifth or one sixth of its maximum breadth. And as there is every reason to assume that the other species did not differ much in that respect from *P. orvini*, it is thus evident that *Phyllolepis* was adapted for a benthonic mode of living.

Endoskeleton of the head.

Any certain traces of substitution bones which may be considered to be from the head have not been found as yet, and one may therefore be justified in assuming that both the endocranium and the visceral endoskeleton were slightly ossified or even entirely unossified. Judging from the broad, flat shape of the head the endocranium must have been broad and low as in many Euarthroires.

The otic region was conceivably very long, a character which otherwise is met with both in several Euarthroires and in certain other Placodermi such as *Gemündina* and *Jagorina* (cf. the chapter on the relationships and classification of *Phyllolepis* etc. below).

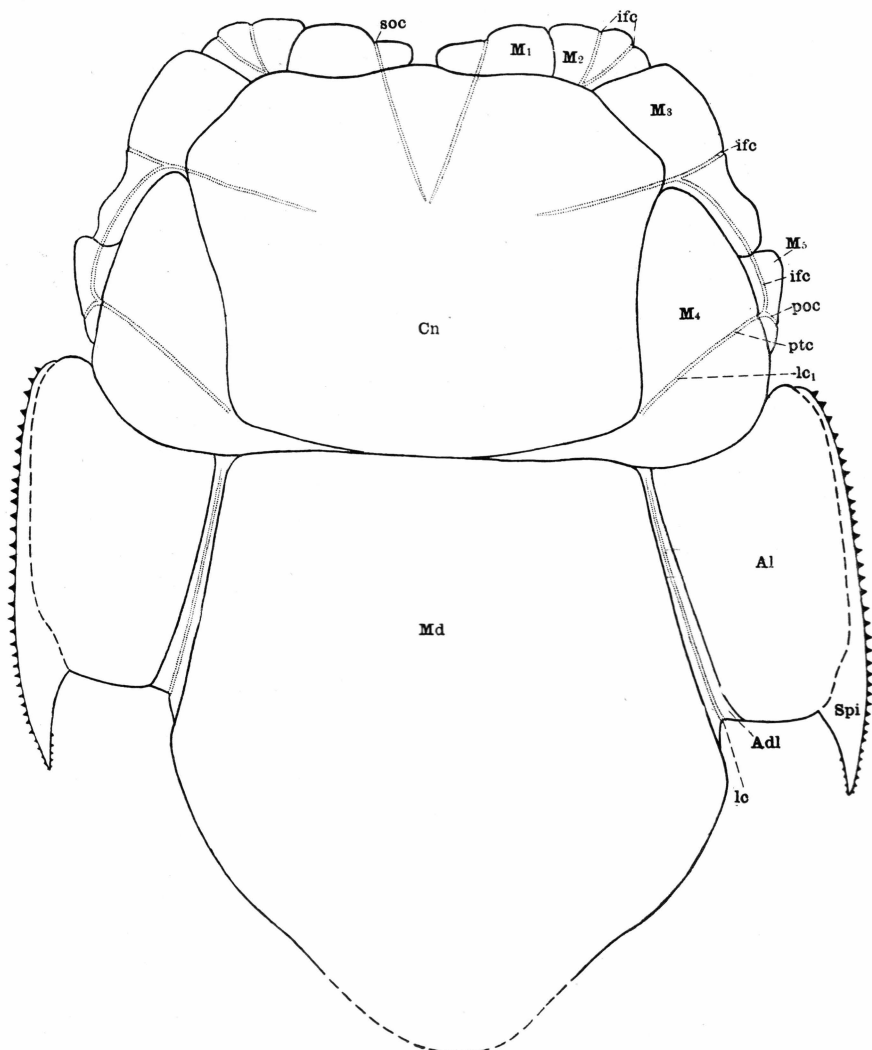
The branchial arches must have been situated ventrally to the head as in the Placodermi in general.

Dermal bones of the head.

As is already well known (STENSIÖ 1934a) no remains have as yet been found of any plates covering the anterior part of the endocranium and the cheeks (text-fig. 9), but whether this condition means that any dermal plates were not present on the said parts of the head or that the dermal plates there were represented only by small vestigial elements situated so loosely in the skin that they became lost during the decaying of the soft tissues must still be left undecided.

The part of the dermal cranial roof found preserved covers the occipital region, the otic region and the most posterior part of the orbito-temporal region, and it is composed of five paired marginal plates and one unpaired median cephalic plates (text-figs. 2, 3, 8, 9, 23, 24).

Four marginal plates (M_1 — M_4) are known already from the earlier descriptions by WOODWARD (1914; 1920), HEINTZ (1930; 1932a) and STENSIÖ (1934a). These four marginal plates have been termed, according to their position from in front backward, marginal plates 1—4. The new material from East Greenland now at my disposal shows, however, that there is also a fifth marginal plate (M_5 , text-figs. 2, 9, 15, 23; pl. 1, figs. 4—6, pls. 9, 25, 28), which is situated immediately behind the marginal plate 3 and laterally to the marginal plate 4, and which is irregularly four-sided in shape. On the exposed part of its external face this fifth marginal plate bears a sensory groove (*ifc*) which forms the straight posterior continuation of the groove in the marginal plate 3 and which divides in a lateral branch (*poc*) which continued laterally



Text-fig. 2. *Phyllolepis orvini* HEINTZ. Attempted restoration of the flattened head and trunk armour in dorsal view. The restoration has been made after a specimen with fairly long median cephalic and median dorsal plates (the specimen in pl. 25. For comparison an attempted restoration of a specimen with short median cephalic and median dorsal plates is given in text-fig. 23). Much diminished. *Adl*, anterior dorso-lateral plate; *Al*, anterior lateral plate; *Cn*, median cephalic plate; *M*₁—*M*₅, marginal plates 1—5; *Md*, median dorsal plate; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *lc*, main lateral line; *lc*₁, cephalic division of the main lateral line; *poc*, preopercular sensory groove; *ptc*, postotic sensory groove; *sc*, supraorbital sensory groove.

on to the skin, laterally to the plate, and a medial very short branch (*ptc*₁) which continues on to the marginal plate 4 on which it goes in a postero-medial direction. As we shall see from the subsequent account,

we are here probably in the unbranched part of the sensory groove (*ifc*) concerned with the most posterior portion of the otic part of the infra-orbital canal, whereas of the two branches of the same groove the lateral one (*poc*) corresponds to the preopercular groove of the Arthrodires and the medial one (*ptc*) to the most anterior part of the postotic canal (cf. SÄVE-SÖDERBERGH 1933, p. 7). The plate shows always one well developed area of a characteristic shape along its medial margin which is overlapped by the marginal plate 4. As will be pointed out more in detail below (cf. under the heading: "Homologues of the dermal bones of the head and trunk") the plate seems to be homologous at least with the posterior part of the marginal plate of the Euarthrodires (cf. text-fig. 10).

Concerning the other marginal plates only little is to be added here.

The marginal plate 1 seem to vary somewhat in shape not only in different species but also in the same species (M_1 , text-figs. 2, 3, 9, 13, 23; pl. 1, figs. 1—3; pls. 25, 28). In certain species (text-fig. 3) it reaches to the median line so as to meet its fellow of the other side, whereas in other species (*Ph. orvini*, text-figs. 2, 9, 23) it is separated from that by a fairly broad gap.

The marginal plates 2, 3 and 4 (M_2 — M_4 , text-figs. 2, 3, 8, 9, 14, 23; pl. 2, fig. 2; pls. 3, 4; pl. 6, fig. 1; pls. 8, 9, 25—28) seem to vary less in shape than the marginal plate 1. The marginal plate 4 lacks all indications of a real joint with the trunk armour. On it we find the main part of the postotic groove (*ptc*) and a long anterior part of the cephalic division of the main lateral line (lc_1). The latter generally ends in the postero-medial part of the plate, close to the postero-lateral corner of the median cephalic plate, but may in exceptional cases continue back to the posterior margin of the plate (text-fig. 9; pl. 4, fig. 2).

The median cephalic plate (Cn , text-figs. 2, 3, 8, 9, 16, 23, pl. 2, fig. 1; pl. 5; pl. 6, fig. 2; pls. 7—9, 25—28) shows, at least in certain species (cf. pp. 34—36 below), a fairly wide range of variation in regard to the ratio between its maximum width and its length. In this connection it should also be mentioned that in *Ph. concentrica*, *Ph. undulata* and in *Ph. orvini*, this plate may in addition to its ordinary three sensory grooves, have also a fourth (*pp*, text-figs. 8, 9; pl. 6, fig. 2) which begins at the postero-lateral corner of the plate and goes in an antero-medial direction. This fourth sensory groove, which conceivably was in communication with the groove regularly found on the marginal plate 4, is probably the homologue of the supposed posterior pit-line in the Euarthrodires.

A gill cover of a similar type to that in the Euarthrodires was developed, but consisted probably entirely or at least mainly of soft tissue.

Trunk armour.

In the description given of it by the present writer in 1934 (STENSIÖ 1934 a) it was shown that the trunk armour, in regard to the plates forming the dorsal and ventral walls and in part also in regard to the plates of the lateral walls, was in many characters of importance as in the Euarthrodiros. From the subsequent account we shall now find that the lateral walls as a whole are of the Euarthrodiran type, though their posterior parts have become much or perhaps even entirely reduced.

The plates actually observed as yet in the trunk armour are as follows: an unpaired median dorsal plate, a paired anterior dorso-lateral plate, a paired anterior lateral plate, a paired spinal plate, an unpaired anterior median ventral plate, a paired intero-lateral plate, a paired anterior ventro-lateral plate and a paired posterior ventro-lateral plate.

The median dorsal plate (*Md*, text-figs. 2, 3, 8, 9, 17, 18, 23, 24; pls. 10—13, 25—28) varies, at least in certain species, much in length. In exceptional cases it bears a paired oblique sensory groove (*lcd*, pl. 10) and certain traces of an unpaired median longitudinal groove (*dx*, pl. 10), the former of which, though it is situated fairly far forwards, is suggestive of the oblique transversal groove found on the median dorsal plate of the Euarthrodiros, whereas the latter, as it seems to be without equivalents in the Euarthrodiros, probably is an accidental structure, arisen in connection with a somewhat excessive development of the sensory groove system in general.

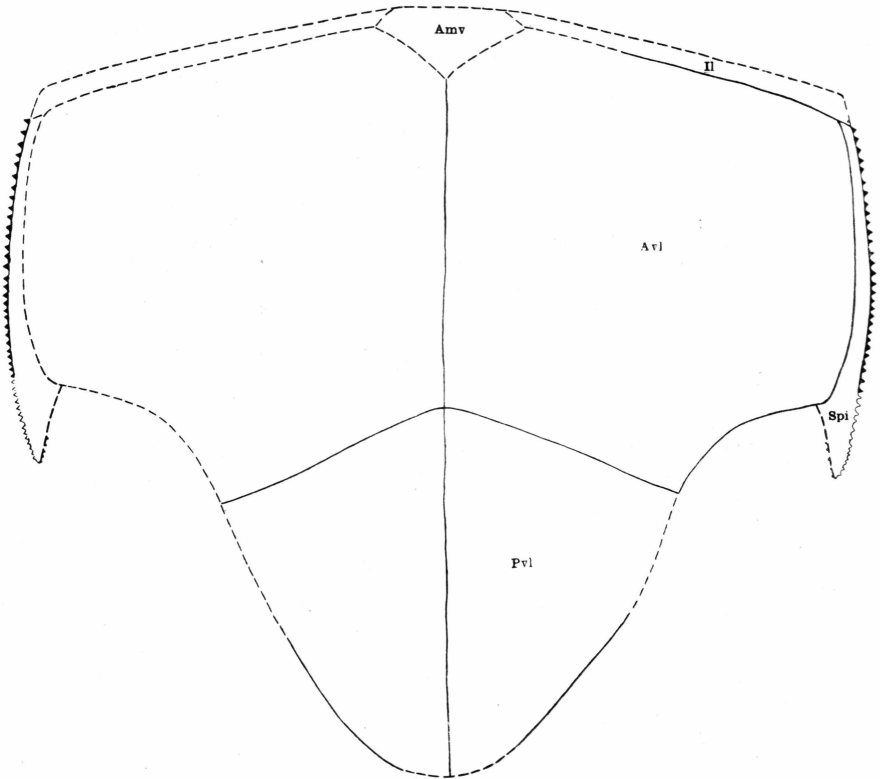
The anterior dorso-lateral plate (*Adl*, text-figs. 2, 3, 9, 23, 24; pl. 14, fig. 2; pl. 17, fig. 4; pl. 18, fig. 2; pls. 25, 27) has at its anterior end, as was shown already in 1934, a dorsal and a ventral large process (*pr*, *pr*₁). It is overlapped by both the median dorsal plate and the anterior lateral plate and both its overlapped areas are well developed; that overlapped by the median dorsal plate is even strikingly broad. Contrary to what was anticipated by the writer (STENSIÖ 1934 a, p. 48), the anterior face of the plate (*a*) shows no certain traces either of any articular trochlea or fossa, and as in addition, as we have seen, also no indications of such structures are to be found on the marginal plate 4, we are led to the conclusion that there was no real joint between the head and trunk. However, it seems almost certain that such a joint originally was present, but that it has become entirely reduced.

The anterior lateral plate (*Al*, text-figs. 2, 3, 8, 9, 19, 23, 24; pls. 15, 25—27) is broad, and forms the main part of the lateral wall of the armour. In the complete specimen of *Phyllolepis concentrica* figured and described by WOODWARD, it was noticed by the writer in 1934 (STENSIÖ 1934 a, p. 20) though it was wrongly considered by him to be the spinal plate. It was also found in the Greenland material dealt with by



Text-fig. 3. *Phyllolepis concentrica* AGASSIZ. Armour in dorsal view. The complete specimen in the Brit. Mus. Photo taken by SÄVE-SÖDERBERGH. Approximately nat. size. *Al*, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Cn*, median cephalic plate; *M*₁—*M*₄, marginal plates 1—4; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *lc*₁, cephalic division of the main lateral line; *mp*, probably middle pit-line; *soc*, supraorbital sensory groove.

the writer in 1934 though it could not be identified at that occasion (STENSIÖ 1934 a, p. 54, pl. 1, fig. 1; pl. 8, fig. 1). It is four-sided and longer than broad. Along its anterior margin it has an area destitute of ornament, an area which was situated a little deeper inwards than the other area of the external face and which was covered from the outside by the posterior, lateral parts of the head. The plate overlaps both the anterior-dorso-lateral plate and the spinal plate, and with the part *a—b* of its

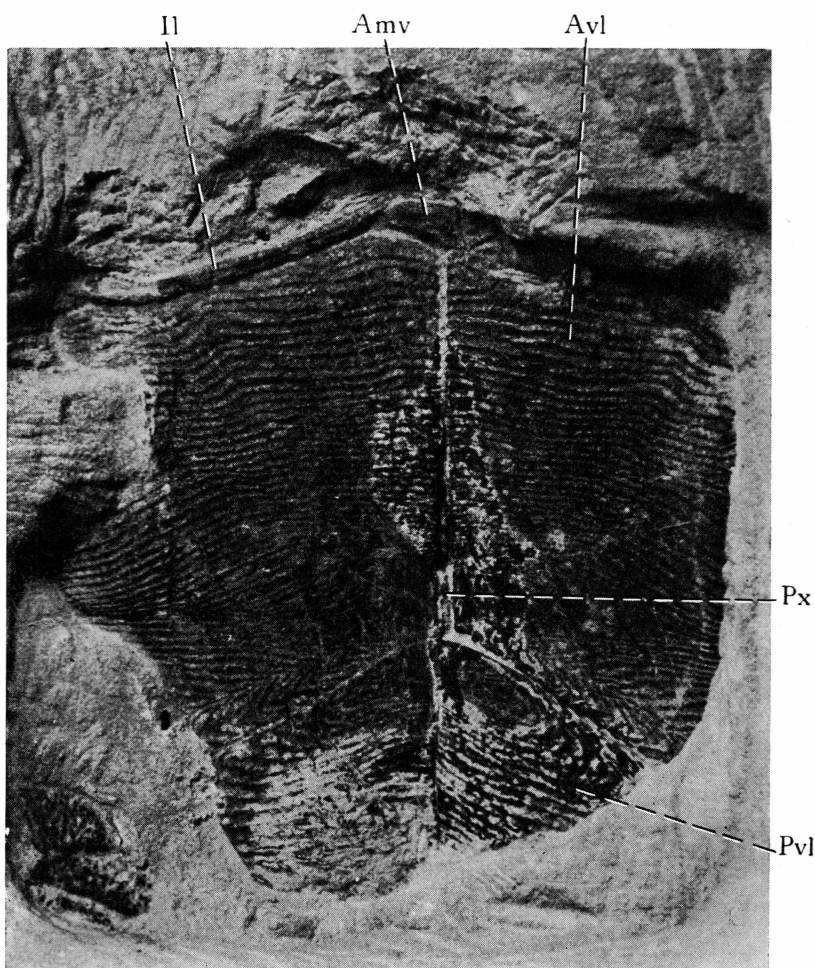


Text-fig. 4. *Phyllolepis orvini* HEINTZ. Attempted restoration of the trunk-armour in ventral view. Cf. text-fig. 24. Much diminished. *Amv*, anterior median ventral plate; *Avl*, anterior ventro-lateral plate; *Il*, intero-lateral plate; *Spi*, spinal plate; *Pvl*, posterior ventro-lateral plate.

anterior margin it was probably in contact with the lateral end of the intero-lateral plate. The area overlapping the anterior dorso-lateral plate (*ov*, text-fig. 19; pl. 15, figs. 1, 2) is, at least in certain species, well defined and in part even somewhat elevated. The area overlapping the spinal plate (*ov*₁, text-fig. 19), which is much broader than the other one, is always indistinctly defined.

The spinal plate (*Spi*, text-figs. 2, 3, 4, 20; pl. 16, figs. 3, 4;

pls. 23—28) is a relatively large element occupied in its interior by a large cavity, a cavity which in at least the two anterior thirds of its length is open medially towards the space surrounded by the trunk armour. With its posterior fourth approximately it projects freely behind



Text-fig. 5 *Phyllolepis concentrica* AGASSIZ. Trunk armour in ventral view. Photo of the complete specimen in the Brit. Mus. taken by SÄVE-SÖDERBERGH. Somewhat enlarged. *Amv*, anterior median ventral plate; *Avl*, anterior ventro-lateral plate; *Il*, inter-lateral plate; *Px*, fragment perhaps of the posterior median ventral plate?; *Pvl*, posterior ventro-lateral plate.

the armour. In the other more anteriorly situated parts it is to a great extent overlapped by the anterior lateral plate on its dorsal side, and by the anterior ventro-lateral plate on the ventral side, only a fairly narrow lateral part of it being freely exposed there. The whole free

lateral margin, which is fairly thick, bears in *Ph. Orvini* three or more series of denticle-like tubercles, which often may fuse into transversally arranged sharp ridges. And in addition also the posterior free part of the posterior margin is provided with low denticle-like tubercles. As we find from the description now given of it the plate is in its size, in its shape and in brief the presence of a large cavity in its interior somewhat suggestive of that in the Acanthaspids.

The anterior median ventral plate (*Amv*, text-fig. 5) is small, triangular and broader than long. It seems to reach only a short distance backwards between the anterior medial parts of the anterior ventro-lateral plates, and in regard to its shape and extent it seems, therefore, to be mostly as in certain Acanthaspids (HEINTZ 1929 a, text-figs. 26, 87; BROILI 1929, pl. 2). As far as can be understood, it is overlapped along each of its postero-lateral margins by the anterior ventro-lateral plate and along each antero-lateral corner by the intero-lateral plate. A large median part of its anterior margin is free, the intero-lateral plates ending already at the lateral part of the plate. The exposed part of its ventral face seems, at least in *Ph. concentrica*, to be ornamented with ridges (text-fig. 5) transversally arranged.

A posterior median ventral plate is perhaps not present or, if so, represented only by some small vestiges (*Px*, text-fig. 5; cf. also STENSIÖ 1934 a, text-fig. 2).

The intero-lateral plate (*Il*, text-figs. 4, 5, 21, 24; pl. 1, fig. 6; pl. 17, figs. 1—3; pl. 23) is, as in the Euarthrodiros (HEINTZ 1929, 1931, pp. 305—306; 1932 b, pp. 175—176, 1933 a, p. 139; 1933 b, pp. 62—65; GROSS 1932, etc.), a slender, transversal element forming the most anterior part of the ventral wall of the trunk armour in front of the anterior ventro-lateral plate and laterally to the anterior median ventral plate. In a corresponding way as in the Euarthrodiros it is composed of a dorsal and a ventral lamina which meet and unite with each other anteriorly at a somewhat rounded angle. On account of that it has such a shape (text-fig. 21) that in a rostro-caudal section it is convex on the antero-ventral (external) side and concave on the postero-dorsal (internal) side. On its antero-ventral side we may therefore distinguish a dorsal and a ventral face, the former of which is directed anteriorly and slightly upwards, whereas the latter, which is ornamented with transversal ridges, is directed downwards and forms a straight anterior continuation of the ventral face of the ventro-lateral plate. Otherwise it should be added here concerning the plate under consideration that it is highest somewhat medially to its lateral end, that it is often curved so that its ventral face is somewhat convex and its dorsal margin medially to the highest part as a whole somewhat concave in a latero-medial direction. The plate is overlapped posteriorly by the anterior ventro-

lateral plate, whereas medially it probably overlapped the lateral corner of the anterior median ventral plate. Laterally, at its lateral end, with the part denoted with the letters *a—b*, it was probably in contact with the anterior lateral plate and possibly also with the spinal plate.

The anterior ventro-lateral plate (*Avl*, text-figs. 4, 5, 6, 22, 24; pls. 19—27) is, as is already known, a large plate. In addition to the margins already described on it in my previous paper (STENSIÖ 1934 a, pp. 49—50) also a short antero-medial margin (*a—b*, text-fig. 22) is to be distinguished on it, a margin which is developed for the connection with the anterior median ventral plate. The anterior margin, which often may be somewhat concave, is in contact with the intero-lateral plate. Judging at least from the new East Greenland material it seems probable that the plate under consideration in *Ph. orvini* in most cases met its fellow of the opposite side in a simple straight suture in the median line, and that accordingly the left plate was only rarely overlapped by the right one (cf. STENSIÖ 1934 a, p. 50; cf. also the description of *Ph. orvini* below). As has already been pointed out above the plate overlaps the intero-lateral plate and probably also the anterior median ventral plate.

Concerning the posterior ventro-lateral plate (*Pvl*, text-figs. 4, 5, 7, 24; pl. 18, fig. 2; pls. 23, 27) nothing new of any importance is to be added here.

Vertebral column.

The notochord was persistent and seems even to have been well developed. The arcual elements (*Arc*, pl. 9) and the neural and haemal spines are all perichondrally ossified only. As they are imperfectly preserved hardly anything of importance can be made out concerning their detailed shape. However, in *Ph. orvini* it could be seen that certain of the anterior arcual elements were pierced by a foramen, but whether these elements were dorsal or ventral ones could not be made sure.

Histological remarks on the dermal bones.

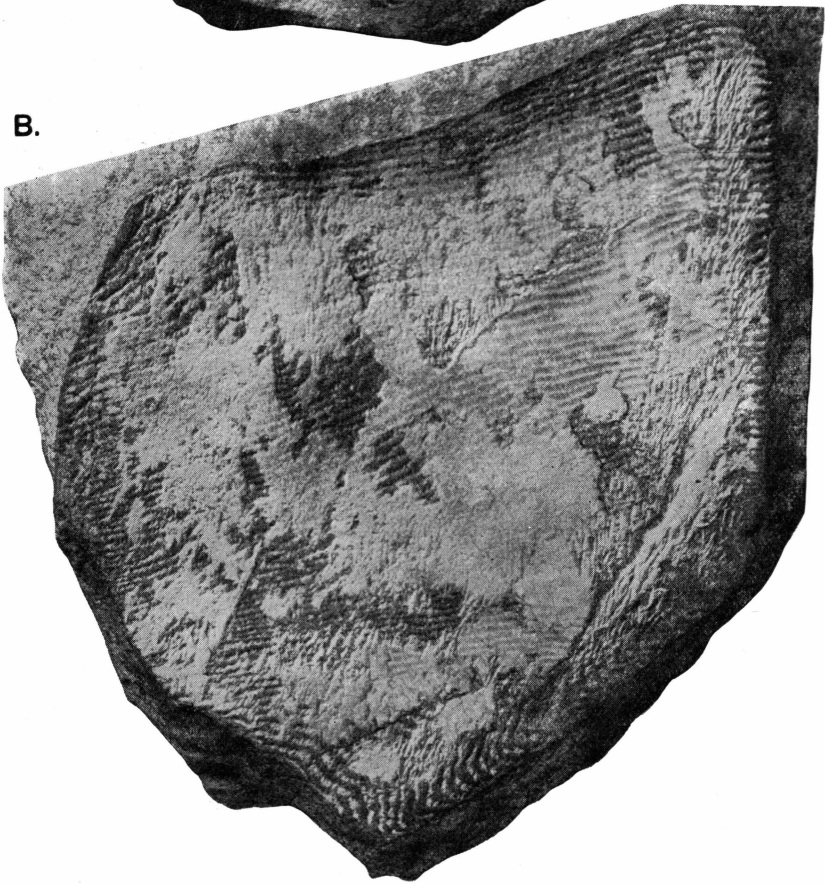
The microscopic structure of the dermal bones of *Phyllolepis* was described for the first time by GROSS in 1934. In the same year it was also dealt with by the present writer in his paper on the Greenland material of *Phyllolepis* (STENSIÖ 1934 a, pp. 22—25). Both these histological accounts agree well with the exception, however, that like HILLS (1931, text-fig. 3, p. 213), GROSS observed a well developed superficial layer ("Skulpturschicht") with laminae parallel with the external face, whereas the writer found such a layer only in a very vestigial development.

In order to control his observations concerning the superficial layer the writer has had numerous new thin sections made from various

A.

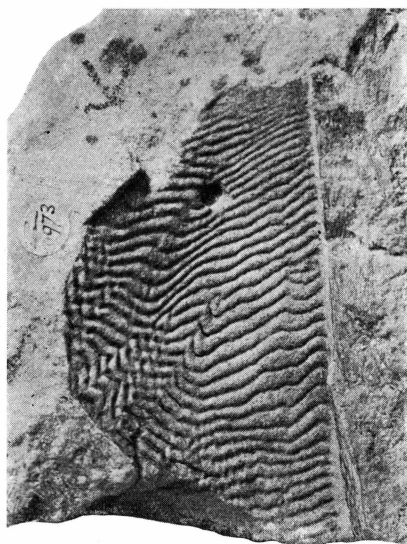


B.



Text-fig. 6. *Phyllolepis concentrica* AGASSIZ. Impression of a posterior part of a left anterior ventro-lateral plate from Elgin in Scotland. B. M. P. 10971. B, *Phyllolepis concentrica*? AGASSIZ. Imperfect left anterior ventro-lateral plate preserved partly as impression of the external (ventral) side. The plate is from Clashbennie in Scotland. Royal Scottish Mus. in Edinburgh no. 1892/101. Somewhat diminished.

plates. And from these new thin sections it is now clear that the layer under discussion here, at least in *Ph. orvini*, is rarely present, being found only in a few plates from the lateral or ventral sides of the trunk armour. As pointed out by Gross it is clearly laminated (pls. 29, 30). Only fairly few of the numerous large Haversian canals of the middle layer (*hav*) continue outwards through it and open on its external face. Besides these Haversian canals a great number of narrow often much winding canals (*cb*), which generally ascend from the outer parts of the Haversian canals of the middle layer, are noticed in it. These winding canals give off numerous, often very narrow branches (*cbr*) which also have a much winding course. Both these winding canals themselves



Text-fig. 7. *Phyllolepis concentrica*, AGASSIZ. Imperfect impression of a left posterior ventro-lateral plate from Rosebrae in Scotland. B.M.P. 10973. Nat. size.

and their branches often lead out to and open on the external face of the layer, and they are probably in places in communication with adjacent ones. In certain of the sections it is clearly seen, however, that several of them end blindly, in other sections it is difficult to make sure how they end. Together they form a plexus-like structure. Owing to the poor state of preservation of the layer nothing could otherwise be made out concerning the minute structure.

Similar narrow winding canals as those described just above in the superficial layer are in several cases clearly present also in the outer parts of the middle layer, though they are generally much less numerous there. In this layer they probably pierce more than one Haversian system of lamellae.

As they have no Haversian lamellae of their own and as in the middle layer they are, as has just been mentioned, quite certainly independent of the Haversian systems the winding canals just described cannot be Haversian canals. And as their lumen is wider than that of the canaliculi of the cell spaces it is evident that they have nothing to do with such canaliculi either. From their appearances and relations it is very likely that they are not normal but secondary structures formed by certain parasitic organisms. Whether they are arisen post mortem or not cannot be ascertained. As far as may be judged they resemble most closely the structures in bone and other hard tissues which have been considered to be caused by the mycelia of thread moulds (cf. KÖLLIKER 1860; ROUX 1887; MOODIE 1926).

In this connection it should be pointed out that GROSS also mentions blindly ending canals in the superficial layer (GROSS 1934) but whether these blindly ending canals are of a similar nature as the ones here described is impossible to make sure from his account.

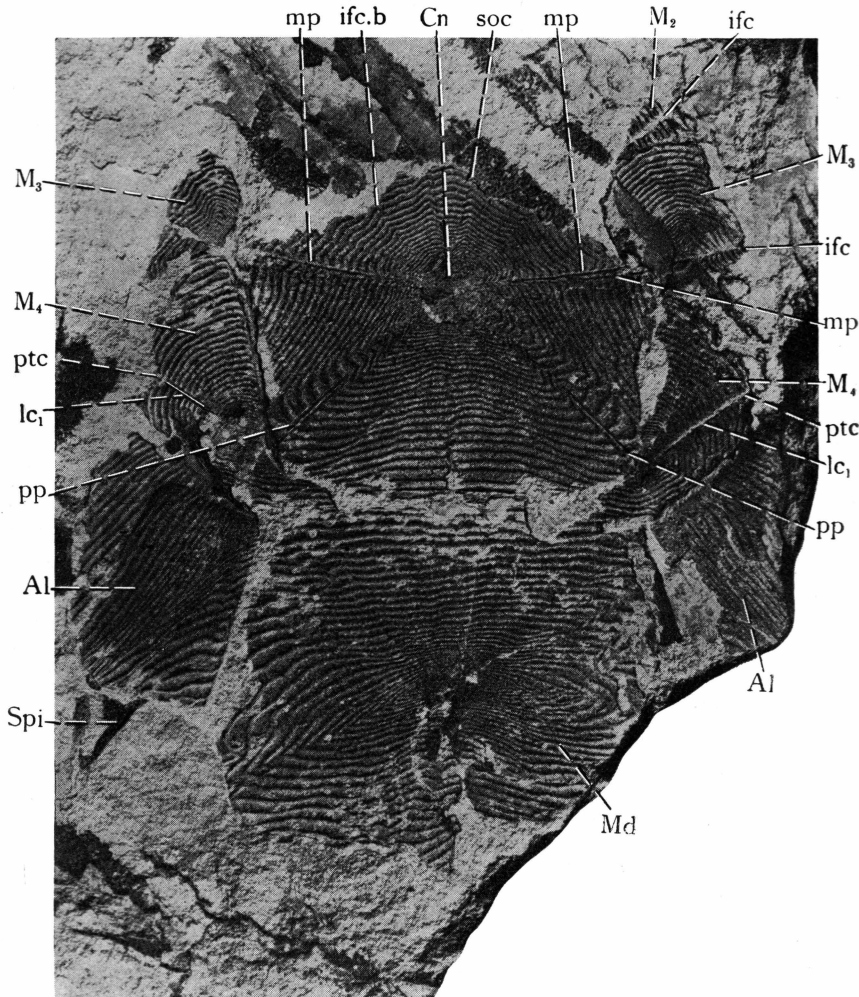
Sensory canal system.

As is already known (STENSIÖ 1934a, pp. 25—29) the sensory canal system is in the fossil condition represented only by grooves. Several of the grooves are fairly wide and well developed, others narrow, shallow and in places sometimes even interrupted. All the grooves are in addition characterized by being widely open outwards, and differ therefore in this respect from the grooves in the Euarthrodires which open outwards only with a narrow slit. The narrow and shallow grooves are in regard to their development mostly comparable to pit lines.

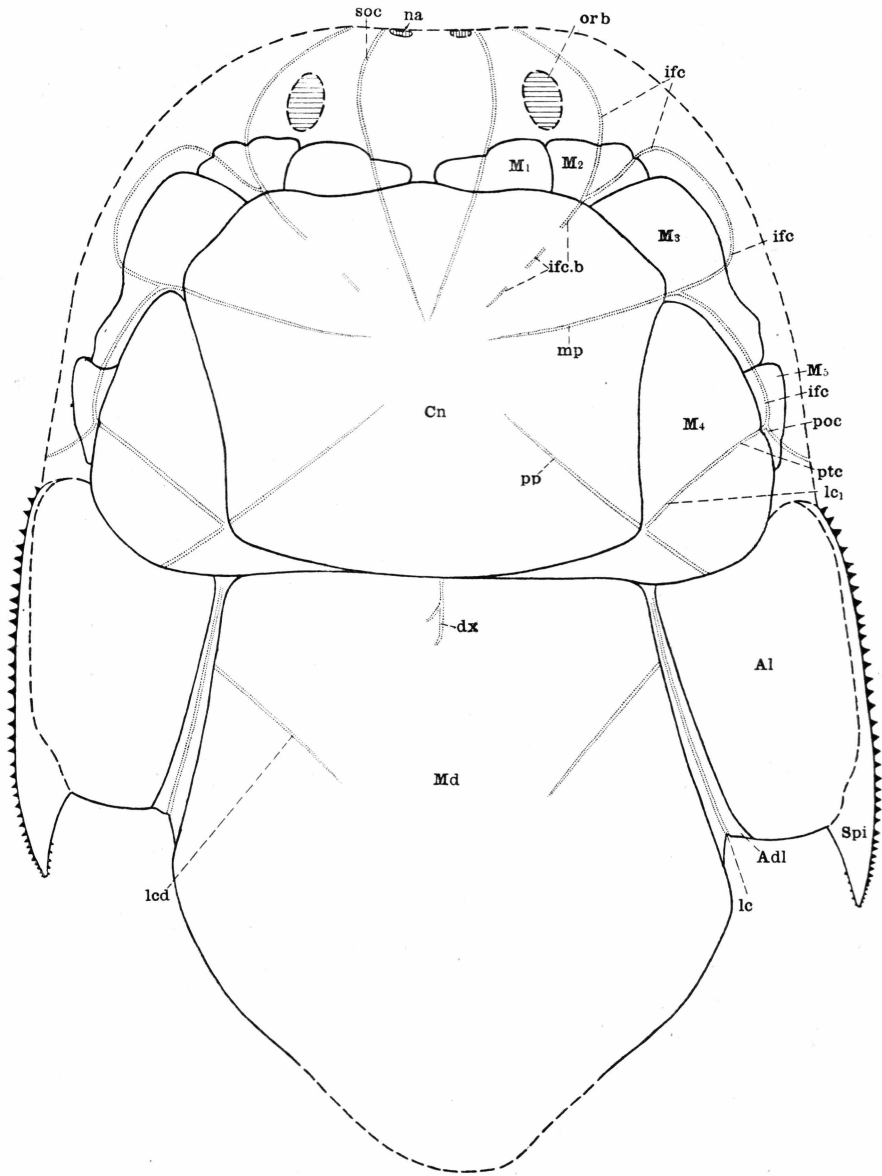
From its development in the fossils it is clear that the sensory canal system had a more superficial position than in the Euarthrodires, a circumstance which, as we shall see, explains why certain parts of it only in exceptional cases gave rise to impressions on the underlying exoskeleton. As is understood from text-figs. 2, 9, 23 and 24 the sensory grooves of the head must in several places have formed sharp bends or loops, a condition which otherwise is generally found only in Selachians and Holocephalians (cf. GARMAN 1888).

The groove (*soc*, text-figs. 2, 3, 8, 9, 23) which has been interpreted as the supraorbital groove began anteriorly on the rostral part of the cranium, that seems to have been devoid of dermal bones. From there it went backward on to the medial part of the marginal plate 1 which it crosses in a posterior and somewhat medial direction. With that direction it continues on to median cephalic plate on which it reaches to or fairly close to the centre. Not rarely it even meets its fellow of the opposite side at that centre. In *Ph. orvini* it is always fairly well developed throughout its extent, though in several cases it becomes shallower

and narrower backwards; in *Ph. concentrica* (at least the only complete specimen known thus far) it is well developed only on the marginal plate 1, whereas on the median cephalic it is represented by a very shallow, interrupted groove only, a groove which for long stretches may even be almost or totally absent (text-figs. 3, 8).



Text-fig. 8. *Phyllolepis concentrica* AGASSIZ. Impression of the dorsal side of the head and trunk armour. Specimen no. 1914/179 in the Royal Scottish Museum in Edinburgh. Certainly the counterpart of the specimen in the Brit. Mus. figured by WOODWARD (cf. text-figs. 3 and 5 in the present work). Approximately natural size. *Al*, anterior lateral plate; *Cn*, median cephalic plate; *M₃*, *M₄*, marginal plates 3 and 4; *Md*, median dorsal plate; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *lc₁*, cephalic division of the main lateral line; *mp*, probably middle pit-line; *ptc*, postotic sensory groove; *soc*, supraorbital sensory groove.



Text-fig. 9. Sketch of a Phyllolepid showing all the sensory grooves observed as yet. The anterior and lateral parts of the head and the course of the sensory grooves on these parts arbitrarily drawn in the figure. Much diminished. *dx*, groove possibly belonging to the sensory canal system; *ifc*, infraorbital sensory groove; *ifc.b*, postero-medial branch of the infraorbital groove; (possibly a posterior division of the supra-orbital groove cf. foot-note on p. 25 below); *lc*, main lateral line; *lc₁*, cephalic division of the main lateral line; *lcd*, dorsal lateral line; *mp*, probably middle pit-line; *na*, possible position of the nasal aperture; *orb*, possible position of the orbit; *poc*, preopercular sensory groove; *ptc*, postotic sensory groove; *soc*, supraorbital sensory groove. For the other letters see text-fig. 2.

Concerning the infraorbital groove only little can be ascertained as yet. As far as can be judged the groove lettered *ifc* on the marginal plate 3 and on the marginal plate 5, in front of *poc*, (text-figs. 2, 3, 8, 9, 23, 24) must be a part of the infraorbital groove. And in addition it is likely that the double groove lettered *ifc* on the marginal plate 2 together with the postero-medial branch *ifc.b*¹⁾ on the median nuchal plate (text-figs. 2, 3, 9, 23, 24) also forms part of that groove.

How the infraorbital groove went in the soft tissue in front of the marginal plate 2 and laterally to that plate and the marginal plate 3 is impossible to make sure at present. The restoration given of its course in text-fig. 9 does therefore not claim to be correct even in the main features, but is intended only to give an idea of a possible connection between the two parts preserved in the fossil.

The branch *ifc.b* supposed to belong to the infraorbital groove may, according to its position, be considered to represent the postero-medial branch of the infraorbital canal of the Euarthroires (text-fig. 10; cf. STENSIÖ 1934 a, p. 28; cf also ALLIS 1934).¹⁾ It is always imperfectly developed. In the only complete specimen of *Ph. concentrica* known as yet (text-fig. 8) it is represented only by one or two short and very indistinct pieces without connection with the parts of the groove situated on the marginal plate 2; in *Ph. orvini* it is in several cases entirely absent (cf. STENSIÖ 1934a, pl. 4, fig. 3), in other cases it is as in the specimen of *Ph. concentrica* just referred to or absent on one side (pl. 2, fig. 1; pl. 7; cf. STENSIÖ 1934 a, pl. 2), whereas in other cases it is developed as a fairly deep and distinct groove which from the groove on the marginal plate 2 reaches for some distance postero-medially, on to the median cephalic plate (pls. 8, 9; cf. STENSIÖ 1934 a, text-fig. 20, pl. 6, fig. 2).

The postotic groove (cf. SÄVE-SÖDERBERGH 1933, pp. 7—8) seems, as far as can be judged, to begin in the marginal plate 5 (*ptc*, text-figs. 2, 9, 23) at the point at which the groove *poc* issues, being in communication there both with the infraorbital groove and the groove *poc*. It goes in a postero-medial direction on to the marginal plate 4, on which it passes over without any boundary into the cephalic division of the main lateral line (*lc*₁).

From its transition into the postotic canal the cephalic division of the main lateral line (*lc*₁, text-figs. 2, 3, 8, 9, 23, 24) passes straight postero-medially to a point on the marginal plate 4 situated close to the postero-lateral corner of the median nuchal plate. There it ends blindly, except in two cases, in *Ph. orvini*, in which (pl. 4, fig. 2) it turns abruptly postero-laterally, and continues back to the posterior margin of the marginal plate 4. Judging from this it is probable that in its most

¹⁾ Cf. foot-note on p. 25.

posterior part it was as a rule situated in the skin dorsally to the exoskeleton.

The groove *poc* (text-figs. 2, 9, 23; pl. 1, figs. 4—6) which from the marginal plate 5 passes postero-latero-ventrally on to the soft tissue of the cheek, agrees in all respects so well with the preopercular groove of the Euarthrodires and Macropetalichthyids (text-figs. 10, 11; cf. STENSIÖ 1925, p. 149—150, 169, 178) that it must be assumed to be the exact homologue of that, on account of which is referred to here as the preopercular groove. Since in the Euarthrodires and *Macropetalichthys* the preopercular groove begins at the transition between the infra-orbital and postotic groove (cf. STENSIÖ 1925, loc. cit.) it is very likely that it does so also here. And accordingly this groove is of much help for the identifying of the longitudinal sensory grooves of the cranial roof both in front of and behind its origin.

The groove *mp* (text-figs. 2, 3, 8, 9, 23, 24) is always well developed. Both in *Ph. concentrica* and *Ph. orvini* it may often be double throughout its extent and in such cases the posterior one of the two grooves is generally much more narrow and shallow than the anterior one (pl. 2, fig. 1). According to its position on the median cephalic plate it may represent either the postero-medial branch of the infraorbital groove of the Euarthrodires (text-fig. 10; cf. STENSIÖ 1925, pp. 168—169, 177; 1931, pp. 143—144; and ALLIS 1934) or the middle head line of pit organs of fishes in general. On account of the circumstance that with its lateral part, situated on the marginal plate 4, it is in communication with the posterior part of the infraorbital groove one would perhaps at first be most inclined to accept the former of the two alternatives of interpretation just mentioned. However, if it is taken into account that the groove *ifc.b*, as pointed out above, at least as far as can be seen at present, seems to represent the postero-medial branch of the infraorbital groove of the Euarthrodires¹), we are instead lead to the assumption that the groove here under discussion (*mp*) corresponds to the middle pit-line of the head. At any rate there is reason to assume that it is homologous to the groove of the Euarthroides considered to represent the middle head-line of pit organs (cf. text-fig. 10), since that groove, if developed laterally, towards the lateral margin of the cranial roof, would also meet and communicate with the infraorbital groove in front of the preopercular groove (cf. STENSIÖ 1925, p. 179; HEINTZ 1932 a, p. 136).

The groove *pp* (text-figs. 3, 8, 9) has as yet been observed only in the complete specimen of *Phyllolepis concentrica* in the British Museum (text-figs. 3, 8), in one specimen in *Ph. undulata* (LERICHE 1931, pl. 1, fig. 1), and in one specimen of *Ph. orvini* (pl. 6, fig. 2). At least in *Ph. orvini*, of which a considerable material is at hand, it is clear that it is only very rarely developed. It is situated on the median cephalic plate on which

¹) Cf. foot-note on p. 25.

it extends from the postero-lateral corner in an antero-medial direction towards the centre, ending, however, already fairly far from that. It is not unlikely that, at least in certain cases, it may have been in communication with the cephalic division of the main lateral line in the marginal plate 4.

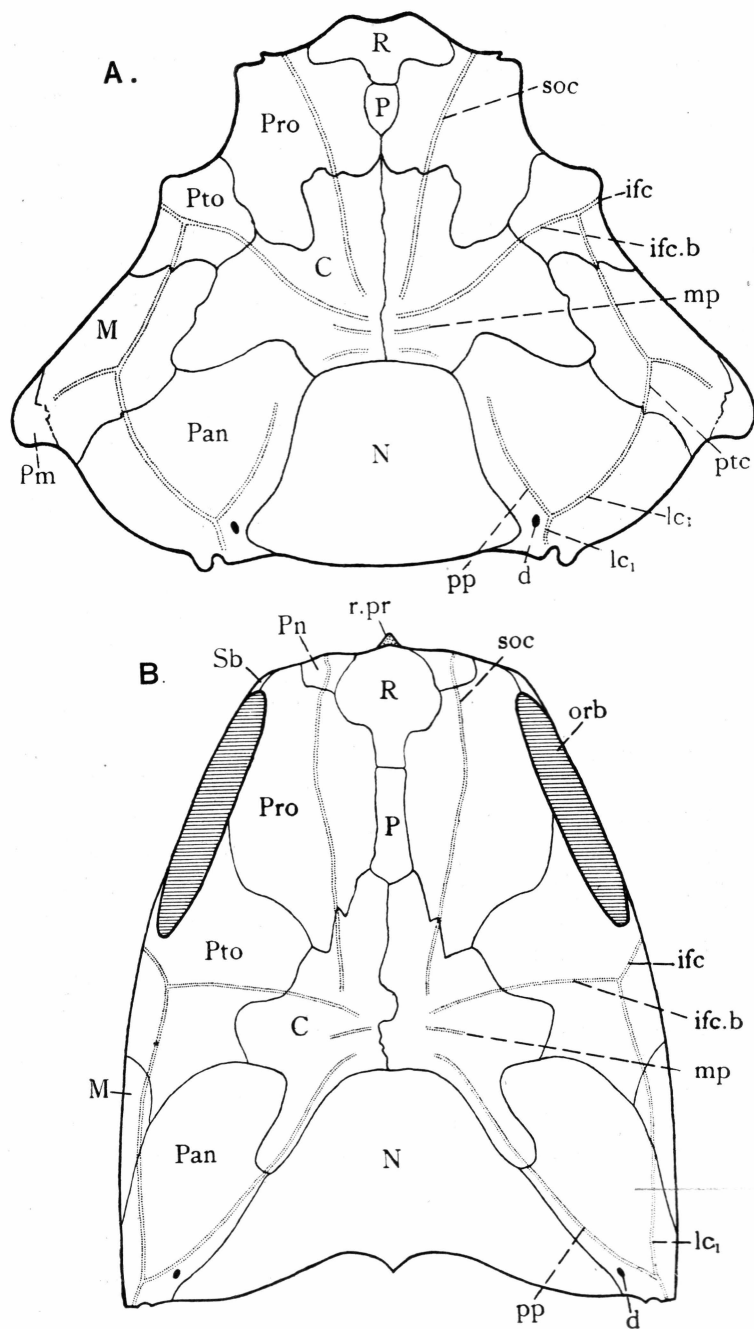
In its position, extent and relations the groove *pp* described just above agrees with the posterior head line of pit organs in fishes in general, particularly, however, with the pit-line so termed in the Euarthroires (text-fig. 10; cf. STENSIÖ 1925, pp. 178—179; 1934 text-fig. 15; GROSS 1932, Abb. 1A, 25B; HEINTZ 1932b, p. 136) which also may be continuous with the cephalic division of the main lateral line (text-fig. 10 B). And one is therefore lead to the conclusion that it really represents that pit-line, at any rate the one so termed in the Euarthroires.

The main lateral line of the trunk is known only in the anterior dorso-lateral plate, which it crosses in a rostro-caudal direction (*lc*, text-figs. 2, 23, 24). In addition to that line there is also in a few cases a paired sensory groove situated on the anterior half of the median dorsal plate, a groove (*lcd*, text-fig. 9) which from the anterior part of the lateral margin of the plate passes for a fairly long stretch postero-medially. This groove, which has been observed both in *Ph. undulata* (LERICHE 1931, pl. 1, fig. 2a) and *Ph. orvini* (pl. 10, on the specimen figured present only on the right side), probably corresponds to the dorsal lateral line of the Euarthroires, though that (cf. HEINTZ 1931, figs. 1, 12A; 1932b, text-fig. 10) is situated much further backwards.

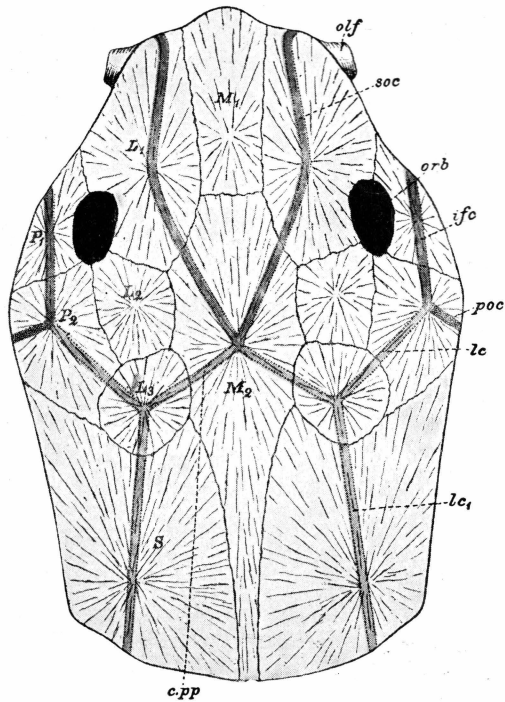
Finally it should be mentioned that in one case in *Ph. orvini* a median unpaired short groove (*dx*, text-fig. 9; pl. 10) is found on the most anterior part of the median dorsal plate, a groove which possibly also belongs to the sensory canal system.

As may be gathered from the account just given of it the sensory canal system is suggestive of that of the Euarthroires in the following characters: 1) the development of all canals as open grooves; 2) the backward extent of the supraorbital groove; 3) the presence of a groove, which conceivably corresponds to the postero-medial branch of the infraorbital groove¹); 4) the presence of a short preopercular groove

¹) In a recent paper ALLIS (1934, pp. 399—400) arrived at the conclusion that the groove termed here by the writer the postero-medial branch of the infraorbital groove, is in fact a posterior division of the supraorbital canal. When I first described it, I was much in doubt whether it should be considered as a part of the supraorbital groove or whether it was a part of the infraorbital groove. (STENSIÖ 1925, p. 168). From the conditions in the Coccosteids I was, however, led to accept the latter alternative (STENSIÖ 1925, p. 177). As I think the objections made by ALLIS against my opinion, at least to some extent, may be right, the groove here under discussion should perhaps be referred to as the posterior division of the supra-orbital groove. [Cf. also the conditions in *Euryaspis* (BRYANT 1934, p. 137 and text-fig. 1) which also seem to support this opinion].



Text-fig. 10. Sketches of the dermal cranial roof with the sensory canal grooves. A. of *Coccosteus*. After HEINTZ 1931, slightly altered, B. of *Pholidosteus*. After STENSIÖ 1934 (1934b). C, central plate; M, marginal plate; N, nuchal plate (median basal); P, pineal plate; Pan, paranuchal plate (externobasal); Pm, post-



Text-fig. 11. *Macropetalichthys rapheidolabis*. Restoration of the dermal cranial roof. Course of the sutures probably in places not fully correct. After STENSIÖ 1925. L_1 , L_2 , L_3 , M_1 , M_2 , P_1 , P_2 , S , dermal bones of the cranial roof; $c.pp$, sensory canal probably corresponding to the posterior pit-lines in fishes in general; ifc , infraorbital sensory canal; lc_1 , cephalic division of the lateral line; poc , preopercular canal; soc , supraorbital canal.

on the postero-lateral part of the cranial roof; 5) the presence and position of the supposed middle and posterior pit-lines of the head; 6) the position and mutual relations of all the sensory grooves on the median dorsal part of the cranial roof; and 7) to a certain extent also the presence and development of the dorsal lateral line. It is therefore clear that it is of the Arthrodiran type, though it is somewhat more specialised than that in the Euarthrodires.

Remarks on the homologues of the dermal bones.

From the knowledge which we possess at present of it and its relations to the sensory grooves it seems now still more probable than earlier

marginal plate; Pn postnasal plate; Pro , preorbital plate; Pto , postorbital plate; R , rostral plate; Sb , suborbital plate; d , opening probably for the canal of the ductus endolymphaticus; ifc , infraorbital sensory groove; $ifc.b$, postero-medial branch of the infraorbital sensory groove (cf. foot-note on p. 25); lc_1 , cephalic division of main lateral line; mp , middle pit-line; pp , posterior pit-line; ptc , postotic sensory groove; soc , supraorbital groove.

(cf. STENSIÖ 1934a, pp. 29—30) that the median cephalic plate comprises both the homologues of the central plates and the homologue of the median nuchal plate of the Euarthrodiros (cf. text-fig. 10). Accordingly this plate seems at least in the main to agree with the large, postero-medial plate in the Macropetalichthyids, (M_2 , text-fig. 11) which, as it is pierced by the posterior parts of the supraorbital sensory canal, probably also includes components homologous at least to parts of the central plates of the Euarthrodiros (cf. STENSIÖ 1925, p. 167).

The marginal plates 1, 2 and 4 seem to represent (cf. STENSIÖ 1934a, p. 30) respectively the preorbital plate, the postorbital plate and the paranuchal plate of the Euarthrodiros (cf. text-fig. 10). The marginal plate 5, cannot on account of its sensory grooves, correspond to the postmarginal plate of the Euarthrodiros. It is therefore almost likely that it and the marginal plate 3 together represents the marginal plate (M , text-fig. 10) of the Euarthrodiros.

In the trunk armour all the plates recognised as yet are certainly directly homologous with the correspondingly termed plates of the Euarthrodiros. And it is therefore clear that the trunk armour is of the same type as in these. The absence of the posterior dorso-lateral plate and the posterior lateral plate is in all probability secondary and due to reduction.

As we thus find from what has just been set forth, the armour as a whole is of the same type as that in the Euarthrodiros.

On the relationships and classification of *Phyllolepis*
with remarks on the classification of the Placodermi
in general.

In 1934 GROSS and the writer (STENSIÖ 1934a, pp. 32—34) showed independently of each other that *Phyllolepis* is a Placoderm allied to the Arthrodiros. The composition of the lateral wall of its trunk armour being at that time in part unknown in part misinterpreted I did not then think it possible to place *Phyllolepis* among the Arthrodiros, but erected provisionally for it a new order *Phyllolepida*, which was classified in the same large group of the Placodermi as the Arthrodiros. The classification of the Placodermi given by the writer at that occasion was as follows:

PLACODERMI.

Group A.

Order *Antiarchi*.

Group B.

1. Order *Phyllolepida*.
2. Order *Arthrodira*.

At present it is clear, however, that *Phyllolepis* agrees with the Arthrodires in many characters of importance e. g. 1) the reduction of the pectoral fin and the presence of a spinal plate representing that fin, 2) the composition of the trunk armour, 3) the shape and position of many of the plates of the trunk armour, 4) the microscopic structure of the dermal bones, and 5) the development and general pattern of the sensory canal system. It must therefore beyond question be much more akin to the Arthrodires than could be suspected earlier. In fact it seems even so closely allied to the Arthrodires that I find it most appropriate to refer it to them. However, as it differs in several respects from the *Euarthrodira* [*Acanthaspida*, *Brachythoraci*¹⁾ (*Coccosteidae*) and *Ptychodontidae*]²⁾ as for instance in the development of the bones of the cranial roof, the presence of a long sensory groove probably representing the middle pit line of the head, the absence or at least strong reduction of the posterior median ventral plate and the much reduced state of the head and trunk armour, it is certainly not so directly related to these that it should be placed to them, but a separate group, *Phyllolepida*, with the same systematic rank as the *Euarthrodita* has therefore been erected for it here. Accordingly the *Arthrodira* would at present comprise two main groups: the *Euarthrodira* [with the subgroups *Acanthaspida*, *Brachythoraci* (*Coccosteida*) and *Ptychondontia*] and the *Phyllolepida* (with *Phyllolepis*).

The much extended knowledge now gained concerning them (BROILI 1930; 1933a; 1933b; STENSIÖ 1925; 1934b, pp. 48—64; WOODWARD 1924; cf. also 1932, p. 60; cf. ROMER 1933) show that the *Stegoselachii* (with the Macropetalichthyids and probably also the Cratose-lachiids) and the *Rhenanida* (with the Asterosteids) in fact have several important characters in common with the Arthrodires. Thus they agree with the Arthrodires among others in the general type of the endocranium, in many of the details of the endocranium (cf. STENSIÖ 1934b, pp. 48—64 and in a forthcoming paper on *Jagorina*), in the general development of the dermal bones of the head, in the general disposition of the sensory canals of the head, and probably also in the development of the visceral skeleton. In addition the *Rhenanida* have, as is seen in *Jagorina*, a dermal shoulder girdle which at least in its anterior and dorsal part is beyond question of a similar type as the trunk armour of the Arthrodires.

As may easily be gathered from what has just been set forth concerning their anatomical characters, the *Stegoselachii* and *Rhenanida* are certainly much more closely allied to the Arthrodires than to the Selachii and Holocephali with which they have recently been grouped

¹⁾ Cf. GROSS 1932, pp. 51—52.

²⁾ Cf. WATSON 1934, pp. 453—460.

by certain writers (cf. BROILI 1933b, ROMER 1933; WOODWARD 1924; 1932, pp. 59—60; etc.). It seems therefore most appropriate to refer them to the *Placodermi* and among these to the same large group as the *Arthrodires*. However, as they differ from the *Arthrodires* in several characters, above all in the presence of well developed and often even strongly developed pectoral fins, they cannot be placed to these but independent subgroups must be erected for them. According to my opinion the classification of the *Placodermi* would therefore be as follows:

PLACODERMI.

Group A.

Subgroup *Antiarchi*.

Group B.

Subgroup I. *Arthrodira*.

Order 1. *Euarthrodira*.

Acanthaspids, Brachyothoracids, Ptychodontids.

Order 2. *Phyllolepid*a.

Subgroup II. *Stegoselachii*.

Macropetalichthyids, Cratoselachids.

Subgroup III. *Rhenanida*.

Asterosteids.

A number of researches carried out in later years on their organisation have shown convincingly that the *Placodermi* are related to the *Selachii* and *Holocephali* and that they probably have evolved from forms closely allied to these (BROILI 1930; 1933a; 1933b; STENSIÖ 1925, pp. 187—189; 1931, pp. 158—160 1934b; WOODWARD 1924; cf. also WOODWARD 1932, p. 42 and ROMER 1933). Expressed in another way, the knowledge which we now have of their organisation seems to indicate with a high degree of probability that the *Placodermi* belong to the same branch of the lower gnathostome vertebrates as the *Selachii* and *Holocephali* (cf. SÄVE-SÖDERBERGH 1934b). For that branch the writer has proposed the term *Elasmobranchi* (STENSIÖ 1931, p. 160), which, as is well known, has hitherto been used only for the *Selachii* and *Holocephali*. The conception of the *Elasmobranchii* and their position among the Gnathostomata (cf. SÄVE-SÖDERBERGH 1934b) would therefore now be as follows.

GNATHOSTOMATA.

Branch I. *Elasmobranchii*.Sub-branch 1. *Acanthodi*¹⁾Sub-branch 2. *Placodermi*.

Group A.

Antiarchi.

Group B.

Arthrodira.

Stegoselachii.

Rhenanida.

Sub-branch 3. *Holocephali*.Sub-branch 4. *Selachii*.Branch II. *Choanata*.

(Crossopterygians, Dipnoans, Urodeles, Anura, Reptiles, etc.).

Branch III. *Actinopterygii*.

(Ganoids and Teleosts).

Description of the Greenland material.

Phyllolepis orvini Heintz.

(Text-figs. 2, 4, 12—24, Pls. 1—30).

Syn. *Phyllolepis orvini* HEINTZ 1930.

— — — 1932 a.

— — STENSIÖ 1934 a.

— *söderberghi* STENSIÖ 1934 a.

— spp. STENSIÖ 1934 a.

Diagnosis. — Very large species, attaining a maximum breadth in the trunk armour of about 32—35 cm. Dermal cranial roof (preserved part) fairly much shorter than the trunk armour. Marginal plate 1 not reaching the median line and not in contact with its fellow of the other side, but separated from that by a gap. Median cephalic plate relatively broad. Ornament somewhat coarse. Superficial layer ("Skulpturschicht") absent or slightly developed on the dorsal plates, but in certain cases present on the lateral and ventral plates.

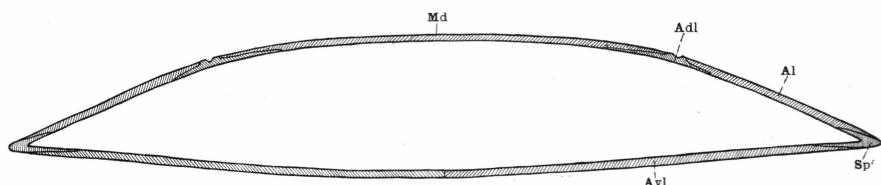
Material. — The material at hand consists of a fair number of detached plates (nos. 331—339, 341—353), but in addition to these it includes also several specimens (nos. 330a-f, 340) in which more or less

¹⁾ The *Acanthodi* are placed here only provisionally and with much doubt. In fact they are so imperfectly known that it is impossible to make sure anything concerning their relationships.

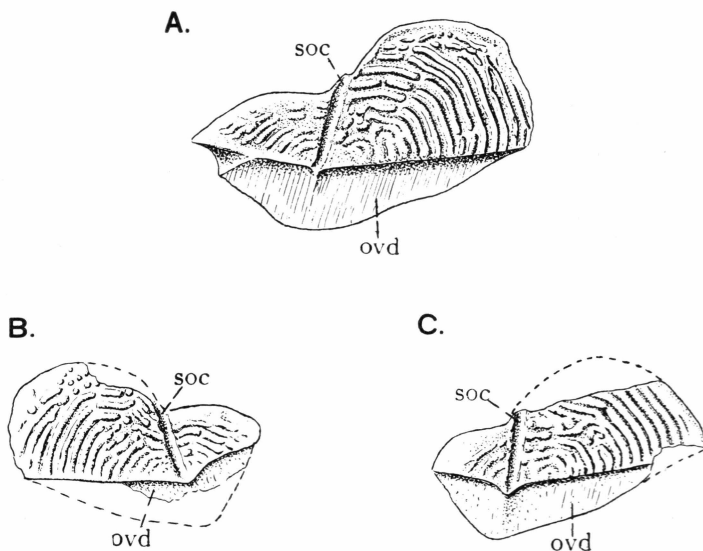
considerable parts of the armour are preserved with the plates somewhat in their natural position in relation to each other. The majority of the last-mentioned specimens are found together in a large piece of rock (pl. 24).

Description. — *Ph. orvini* attains a large size, the largest specimens met with of it measuring in breadth across the trunk armour not less than about 32—35 cm by a total length which may be estimated to at least 50—60 cm. On the other hand the height was very small. Thus in the trunk-armour in which it may be ascertained with some accuracy it was only about one fifth or one sixth of the breadth.

The marginal plates 1—3 show often indications of reduction along their free margins, the parts of them situated along these margins being



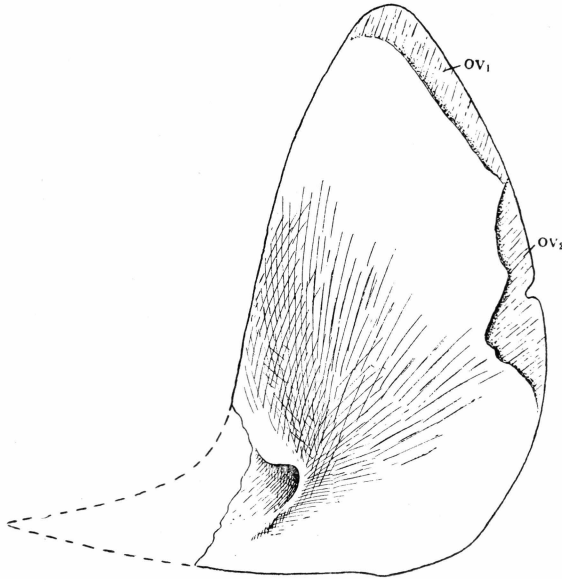
Text-fig. 12. *Phyllolepis orvini* HEINTZ. Sketch showing the probable shape of the trunk armour in a transverse section. Approximately one half of the nat. size. *Adl*, anterior dorso-lateral plate; *Al*, anterior lateral plate; *Avl*, anterior ventro-lateral plate; *Md*, median dorsal plate; *Sp*, spinal plate.



Text-fig. 13. *Phyllolepis orvini* HEINTZ. Marginal plate 1 from two different individuals. A, of the right side. Specimen in pl. 9. B, of the left side. Specimen in pl. 25. C, of the right side of the same individual as B. Nat. size. *soc*, supraorbital sensory groove (part); *ovd*, overlapped area.

thin, devoid of ornament and often notched in a somewhat irregular way (text-figs. 2, 9, 13, 23; pl. 1, figs. 1—3; pls. 9, 25; cf. also STENSIÖ 1934a, text-figs. 16—18; pl. 1, figs. 2—5; pl. 2; pl. 4, fig. 1; pl. 8, fig. 2; pl. 16, fig. 1).

The marginal plate 1 (M_1 , text-figs. 2, 9, 13, 23; pl. 1, figs. 1—3; pls. 25, 28) varies fairly much in shape. Both the types of it described earlier by the writer (STENSIÖ 1934a, p. 40) being found in the species. The plate is overlapped only by the median cephalic plate. The ornament, which may be absent on the medial part of the plate, consists of ridges approximately concentric with the medial, anterior and lateral margins.



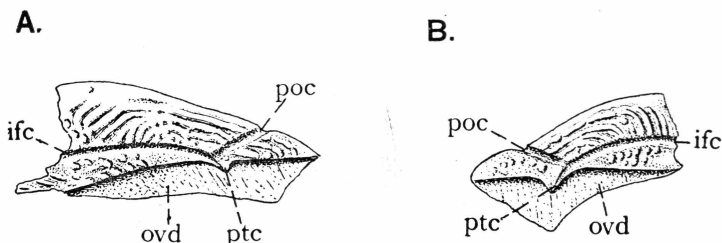
Text-fig. 14. *Ph. orvini* HEINTZ. Marginal plate 4 in medial view showing the areas overlapping the posterior part of the marginal plate 3 (ov_1) and the marginal plate 5 (ov_2). $\frac{3}{4}$.

The marginal plate 2 (M_2 , text-figs. 2, 9, 23; pls. 25, 28) seems to be fairly constant both in regard to shape and ornament. Nothing of any importance is therefore to be added here to the earlier description given of it (STENSIÖ 1934a, pp. 40—41).

The marginal plate 3 (M_3 , text-figs. 2, 9, 23; pl. 2; fig. 2; pls. 3, 9, 25, 28) is probably also fairly constant, at least in shape (cf. STENSIÖ 1934a, pp. 41—42). In addition to its medial overlapped areas (ovd_1 , ovd_2) it has also an anterior area (ov , pl. 3, fig. 1), by means of which it overlaps the marginal plate 2. At its posterior end it shows neither any overlapped nor any overlapping area and its connection with the marginal plate 5 was therefore probably fairly loosely.

The marginal plate 4 (M_4 , text-figs. 2, 9, 14, 23; pl. 2, fig. 2; pl. 4; pl. 6, fig. 1; pls. 8, 9, 25, 27, 28) seems to vary only somewhat in breadth. Laterally it overlaps both a posterior part of the marginal plate 3 (ov_1) and the marginal plate 5 (ov_2). In two cases it bears a posterior continuation of the cephalic division of the main lateral line, a posterior continuation (cl_1 , pl. 4, fig. 2) which goes in a postero-lateral direction to the posterior margin.

The marginal plate 5 (M_5 , text-figs. 2, 9, 15, 23, 24; pl. 1, figs 4, 5; pls. 9, 25, 28), which varies much in size, and which is small as compared with the other marginal plates, is longer than broad and four-sided in shape with the shortest margin backwards and the longest margins medially and laterally, respectively. Along its medial margin it has a fairly broad area (ovd), which is overlapped by the marginal plate 4. Anteriorly it seems, as already mentioned, to have been connected with the posterior end of the marginal plate 3 only with its very margin. And

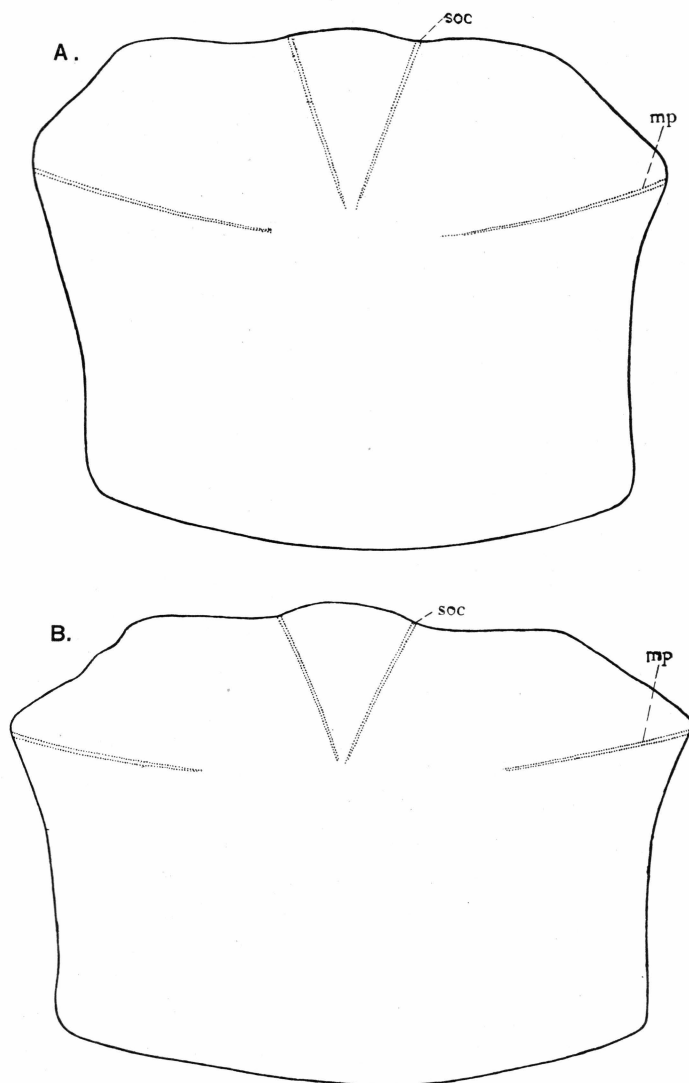


Text-fig. 15. *Phyllolepis orvini* HEINTZ. Marginal plate 5 from two specimens of approximately equal size. *A*, from the specimen in pl. 25. *B*, from the specimen in pl. 28. Nat. size. *ifc*, infraorbital groove (most posterior part); *ovd*, area overlapped by the marginal plate 4 *poc*, preopercular groove (dorsal part); *ptc*, postotic groove (short anterior part only).

as thus its connection with the cranial roof was not particularly strong it is easily understood that it has often become detached and got lost. The exposed area bears the most posterior part of the infraorbital sensory groove (*ifc*), a short anterior part of the postotic groove (*ptc*), and a short dorsal part of the preopercular groove (*poc*). The plate is ornamented with ridges concentric with the anterior and lateral margins.

The median cephalic plate (Cn , text-figs. 2, 9, 16, 23, 24; pl. 2, fig. 1; pl. 5; pl. 6, fig. 2; pls. 7, 8, 9, 25, 26, 28) varies somewhat in regard to the proportions of its maximum width and its length in the median line. Thus it is in certain specimens fairly long and narrow (text-fig. 14A; pl. 25; cf. STENSIÖ 1934a, pl. 3), whereas in other specimens it is shorter and broader (text-fig. 14B; pl. 28; cf. STENSIÖ 1934a, pl. 2). The ratio between its maximum width and its length in the median line is in the longest and narrowest types about 1,20—1,26, in the intermediary types, which seem to be rarer than the other ones about 1,30, and in the

broadest types about 1,35—1,37. The longest and narrowest types of the plate are found in those specimens in which the median dorsal plate is long, the shortest and broadest types in those specimens in which the median dorsal plate is fairly short, and it is therefore obvious that there is a certain correlation in regard to shape between the plate here under description and the median dorsal plate. The area of the plate overlapping the marginal plate 1 (*ov*₁, pl. 5) does not extend to the median



Text-fig. 16. *Phyllolepis orvini* HEINTZ. Two median cephalic plates. *A*, of a fairly long and narrow type (the specimen in pl. 25); *B*, of a fairly short and broad type (the specimen in pl. 28). ³/₄. *mp*, probably middle pit-line of head; *soc*, supra-orbital sensory groove.

line, a condition which shows beyond question that the marginal plate 1 did not meet its fellow of the opposite side in the median line, but was separated from it there by a median gap approximately as shown in text-figs. 2, 9 and 23.

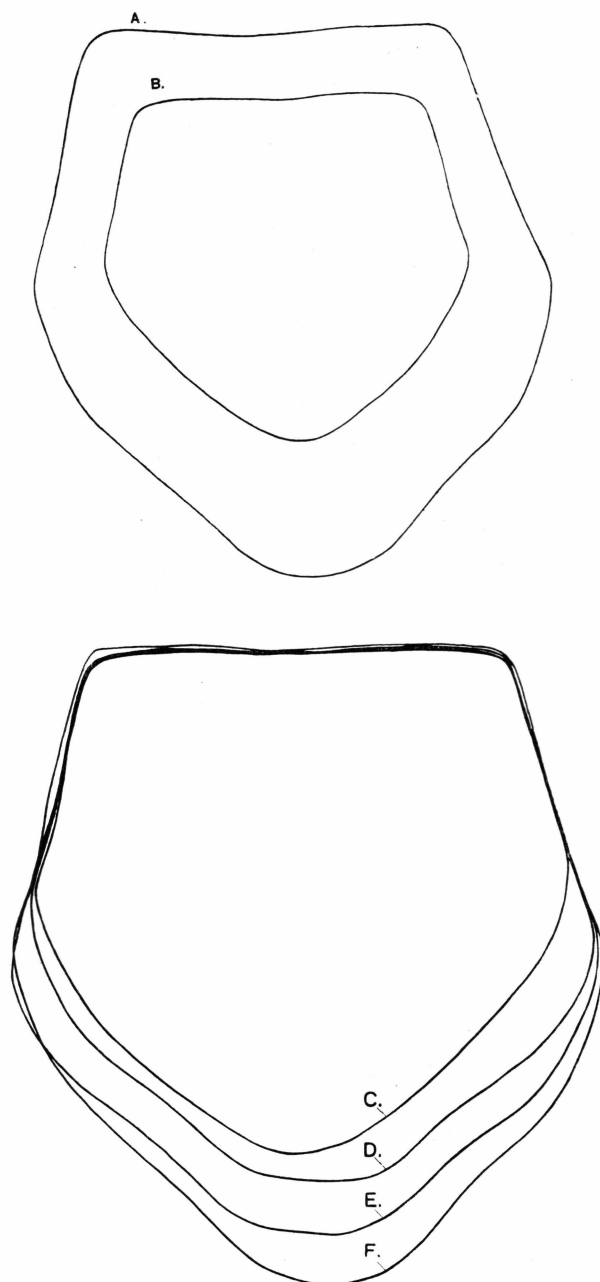
The median dorsal plate (*Md*, text-figs. 2, 9, 17, 23, 24; pls. 10—13; 24—28) is of a fairly different length in different individuals. In fact the variation of the length (text-fig. 17) amounts to about 17—25 per cents. Also its ornament varies somewhat, being in certain individuals, such as that shown in pl. 13 and as that in text-fig. 18, a little more delicate in the central parts than is the case in other specimens (pls. 10—12).

With the extended knowledge which we have now gained of the median dorsal plate, it is very unlikely that the specimen of this plate (text-fig. 18), which was chosen as a holotype of the species (STENSIÖ 1934a, p. 34), was as short as supposed by HEINTZ (cf. HEINTZ 1930, pl. 3; 1932a, text-fig. 7). According to the writer's opinion it was at least as long as shown in the restoration given in text-fig. 18. It is even likely that it may have been of a similar length as the plate shown in pl. 13.

Before leaving the median dorsal plate it should also be added that in one case (pl. 10) it bears a paired sensory groove (*lcd*), which seems to correspond to the dorsal lateral line in the Arthrodires, and that in addition in the same case it also has indications of a short median unpaired sensory groove (*dx*), which seems to be without any equivalent in the Arthrodires and which, as already mentioned, probably is only an occasional structure.

Concerning the anterior dorso-lateral plate (*Adl*, text-figs. 2, 9, 23, 24; pl. 14, fig. 2; pl. 17, fig. 4; pl. 18, fig. 2; pls. 24—27), it is only worthy of notice here that it lacks indications of a joint on its anterior face (*a*) (cf. STENSIÖ 1934a, pp. 47—48).

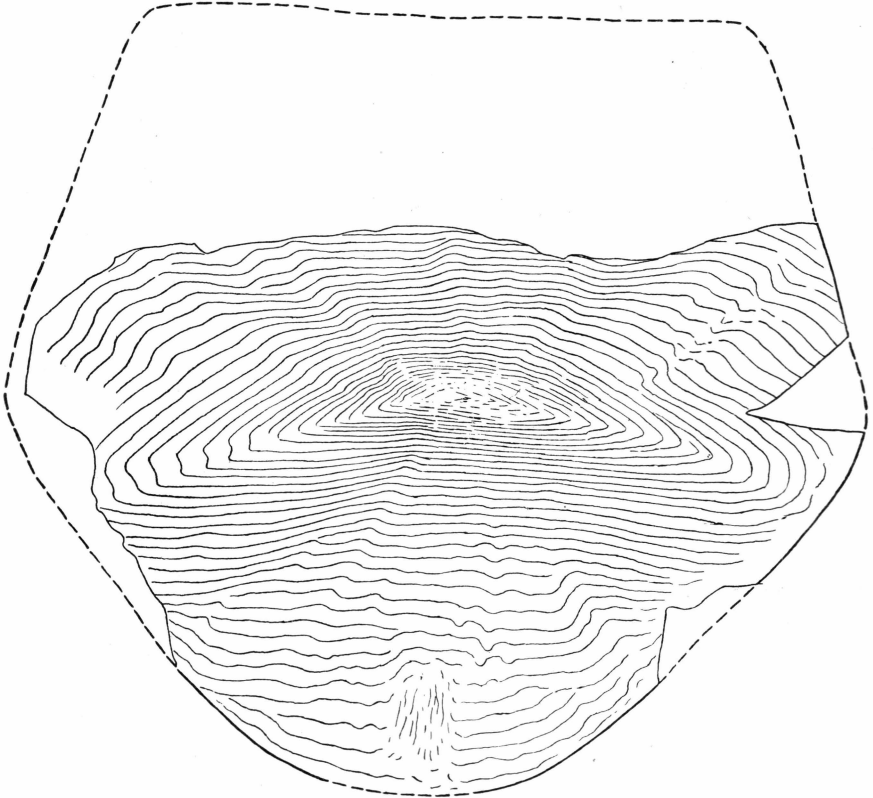
The anterior lateral plate (*Al*, text-figs. 2, 9, 19, 23, 24; pls. 15, 25—27) is four-sided and much broader than the anterior dorso-lateral plate. The anterior margin, which is directed fairly much dorsally, was probably with its part *a—b* in contact with the intero-lateral plate; the dorso-medial margin, which is long, is slightly convex; the posterior margin, which is the shortest of the four, may be either straight or slightly concave; and finally the ventro-lateral margin, which is the largest of all, is as a whole slightly convex but often with an at least small concavity towards its posterior end. The external (lateral) face is somewhat convex and the internal (medial) face somewhat concave in a transverse direction. The area overlapping the anterior dorso-lateral plate (*ov₁*) is well defined, being situated at a somewhat higher level than the internal (medial) face otherwise and also often separated from the other parts of the internal face by a sharp, narrow ridge (*r*). The area overlapping the spinal plate (*ov₁*) is broad but by far not so



Text-fig. 17. *Phyllolepis orvini* HEINTZ. *A, B*, outlines of a long and a short median dorsal plate, *A* from the specimen in pl. 26. *B* from the specimen figured by the writer in 1934 in pl. 11. *C—F*, Outlines of four median dorsal plates showing the variation in length (by equal length of the anterior margin). *C* the same plate as in fig. *A*. *D* from the specimen in pl. 28. *E* from the specimen in pl. 27. *F* from the specimen in Pl. 26 (the same as in fig. *B*). All the figures much diminished.

well defined as the one just described. Any certain indications of an area for the overlapping of a possible posterior lateral plate cannot be detected. The ornament consists of long, somewhat undulating ridges arranged in two areas in the way shown in text-fig. 19 (cf. STENSIÖ 1934a, pl. 1, fig. 1 and pl. 8, fig. 1).

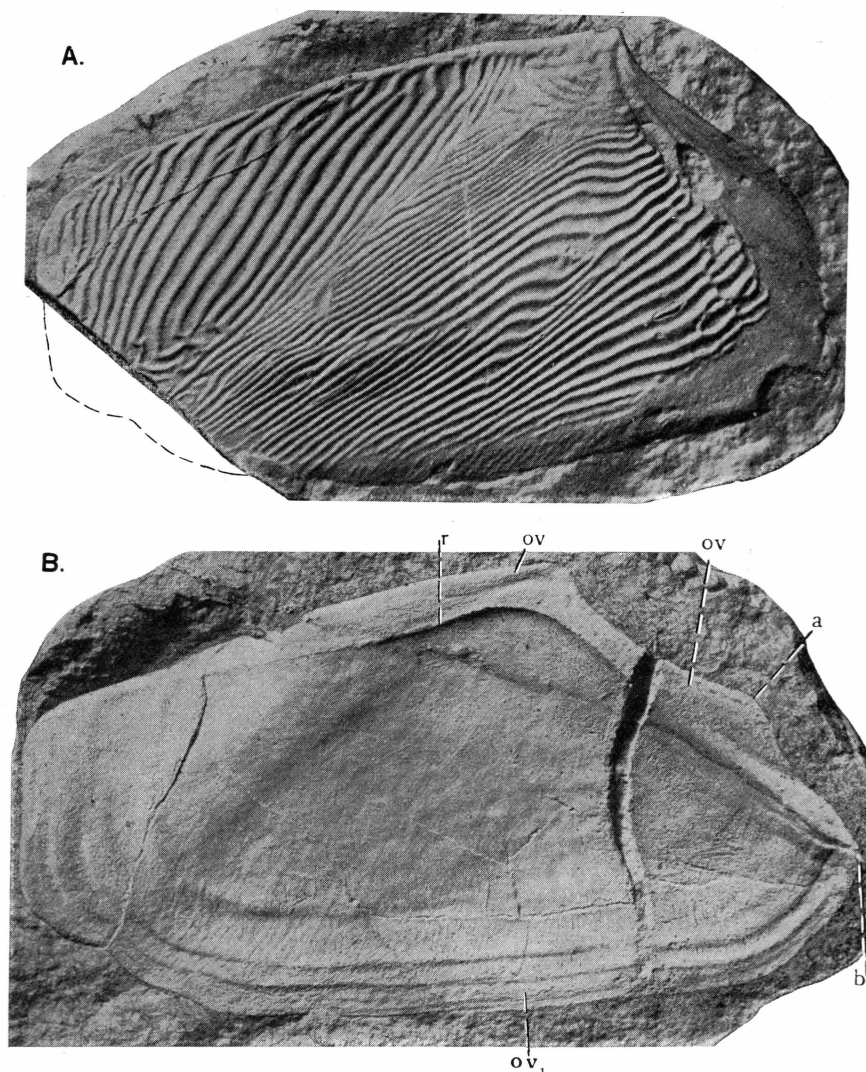
The spinal plate (*Spi*, text-figs. 2, 9, 20, 23, 24; pl. 16, figs. 3, 4;



Text-fig. 18. *Phyllolepis orvini*. Probable shape of the median dorsal plate chosen as holotype. Restoration based on what is actually present of the plate. Diminished.

pls. 23—28) is long and well developed. In its anterior two thirds, in which the cavity in its interior is open medially, we may distinguish in it a dorsal and a ventral lamina, which merge into each other laterally and of which the ventral one is broader than the dorsal one. From its anterior end, where it is narrow, the plate increases gradually in breadth backwards to about the transition between the middle and posterior thirds of its length, then decreasing in breadth backwards to its posterior end, which is fairly pointed. It presents five margins, which are as follows: an anterior margin, which is very short and almost straight; a lateral

margin, which is the longest of all, and which is somewhat convex; a medial free margin, which is fairly short and somewhat concave; an overlapped medial dorsal margin (on the dorsal lamina), which is fairly straight; and finally an overlapped medial ventral margin (on the ventral laminae), which is slightly convex. The lateral margin, which throughout the greater part of its length is not edge-shaped but obtusely rounded



Text-fig. 19. *Phyllolepis orvini* HEINTZ. Anterior lateral plate. A, from the right side in lateral view with the ornament. B, in medial view. (A, cast of the specimen no. 353 B, from the left side after the specimen figured in pl. 15, fig. 2. Somewhat diminished. *a—b*, part of the anterior margin that probably was in contact with the antero-lateral plate; *ov*, *ov*₁, areas overlapping respectively the anterior dorso-lateral plate and the spinal plate.

off, is provided with spine-like tubercles. These tubercles, which at any rate are present in three rows, may often be confluent with each other in a transverse direction, forming in this way sharp transverse ridges. A series of tubercles is also present on the posterior free margin of the plate. The plate is overlapped to such a large extent that only the posterior third and a narrow lateral strip of the anterior two thirds are exposed. With regard to its size, shape and development as a whole, it is, as we find, mostly as that in the *Acanthaspids*.

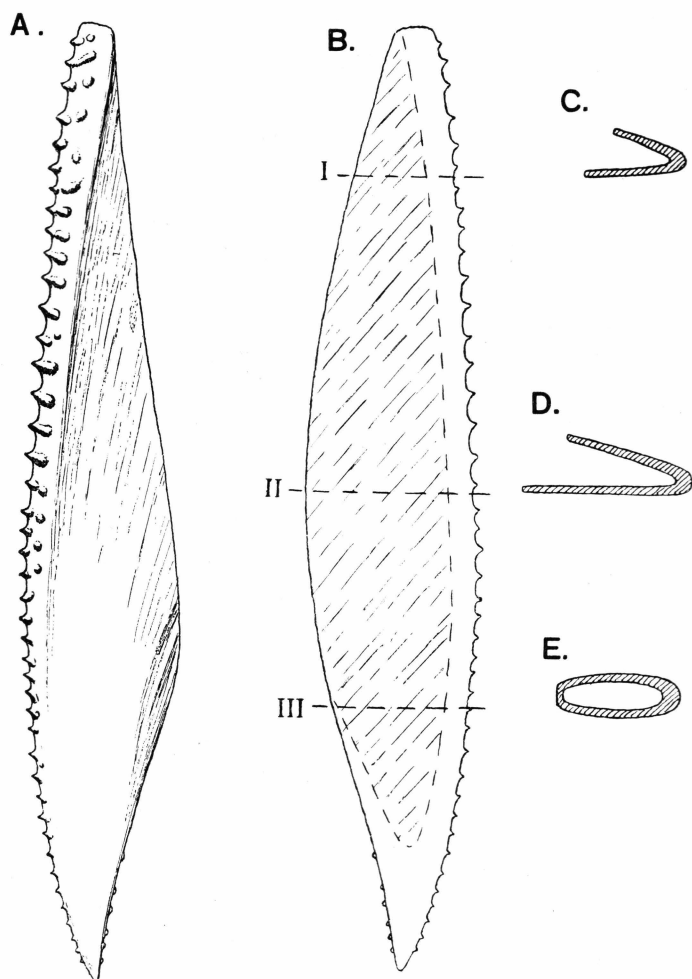
Before leaving the spinal plate it should be mentioned that the fragment figured by the writer (STENSIÖ) in pl. 17, fig. 3 in 1934 (1934a) is an impression of a lateral part of a spinal plate with sharp transverse ridges.

The anterior median ventral plate is not found preserved as yet, but from the shape of the anterior ventro-lateral plate it is easily seen that, as in *Ph. concentrica* (text-fig. 5), it must have been small and of a broadly triangular shape. Its anterior margin was certainly freely exposed for a long stretch between the intero-lateral plates.

The intero-lateral plate (*Il*, text-figs. 4, 21, 24; pl. 1, fig. 7; pl. 17, figs. 1—3) is clearly of a similar type to that in the *Euarthrodiros*. It is higher in its lateral than in its medial parts, and at least in certain cases it is somewhat curved so as to have its ventral side somewhat convex in a latero-medial direction and its dorsal side correspondingly concave in the same direction. Medially it ends already far from the median line, and it is therefore obvious that it can only have been in contact with or have overlapped a fairly short lateral part of the anterior median ventral plate. It was therefore in this respect as in *Ph. concentrica* (text-fig. 5). A posterior narrow part of its ventral face (*ovd*) was overlapped by the anterior ventro-lateral plate. The other part of that face, thus the part which was freely exposed, is at least in certain cases ornamented with latero-medially running ridges.

The anterior ventro-lateral plate (*Avl*, text-figs. 4, 22, 24, pls. 19—27) varies somewhat in its proportions in different species. In addition to the margins earlier distinguished by the writer on it, it presents also an antero-medial margin (*a—b*, text-fig. 22) which is short and fairly straight. This margin was in contact with the anterior median ventral plate. Concerning the anterior margin it should be added here that it often may be slightly concave, particularly in its middle part. The medial margin probably as a rule did not meet that of the other side so as to overlap or to be overlapped by that, as in the specimen described by the writer in 1934 (STENSIÖ 1934a, pp. 49—50), but formed generally with that only a simple straight suture. In addition to the area (*ov₄*) overlapping the posterior ventral plate and the areas (*ov₃*, *ov₁*) for the overlapping of the spinal and median ventral plates, the plate

here under consideration must also have had a narrow area (ov_2) for the overlapping of the intero-lateral plate (pl. 19). The last-mentioned area is, however, so slightly marked that hardly anything is to be seen of it. As is seen from text-fig. 22 and pls. 20—22 (cf. also STENSIÖ 1934a,



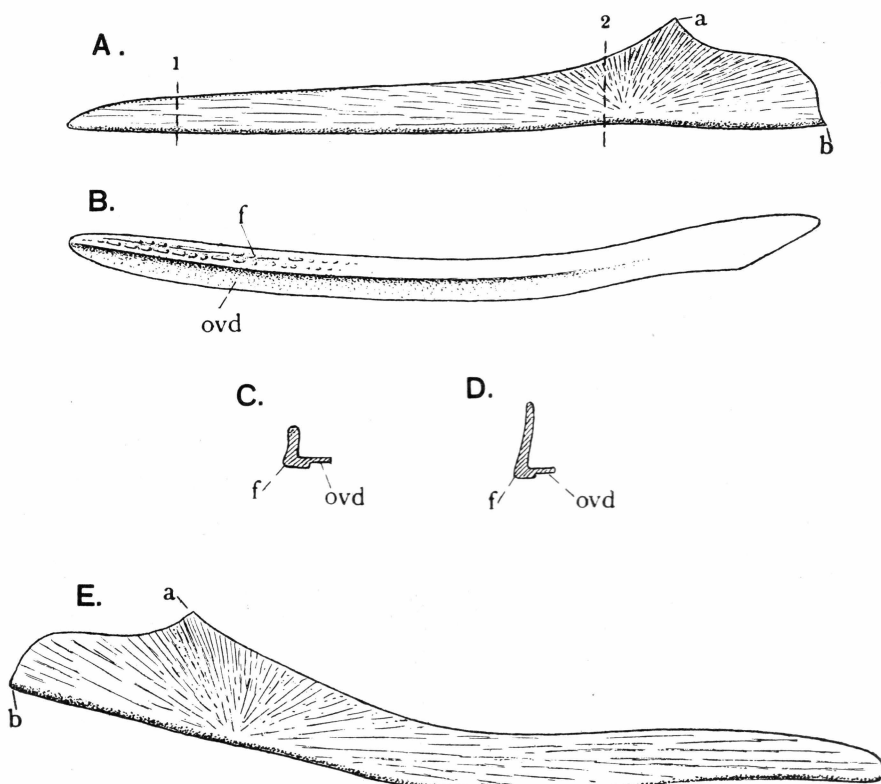
Text-fig. 20. *Phyllolepis orvini* HEINTZ. Spinal plate. *A*, in dorsal view; *B*, outlines of the same spinal plate in ventral view with the extent of the internal cavity indicated with oblique lines. *C*, *D*, *E*, transversal sections at the planes denoted with I, II and III respectively. Nat. size.

text-figs. 24, 26; pls. 6, fig. 1; pl. 12; pl. 13, fig. 1; pl. 14), the ornament shows a fairly wide range of variation.

The posterior ventro-lateral plate (*Pvl*, text-figs. 4, 24; pl. 18, fig. 2; pls. 23, 24, 27; cf. also STENSIÖ 1934a, text-figs. 24, 26; pl. 16,

fig. 2 and pl. 17, figs. 1, 2) is in the new material at hand represented only by a few imperfect specimens, and I have therefore nothing of any importance to add here to our knowledge of it (cf. STENSIÖ 1934a, pp. 51—54).

As may be gathered from the account of its various plates just given, the armour must have varied with regard to the ratio between its length

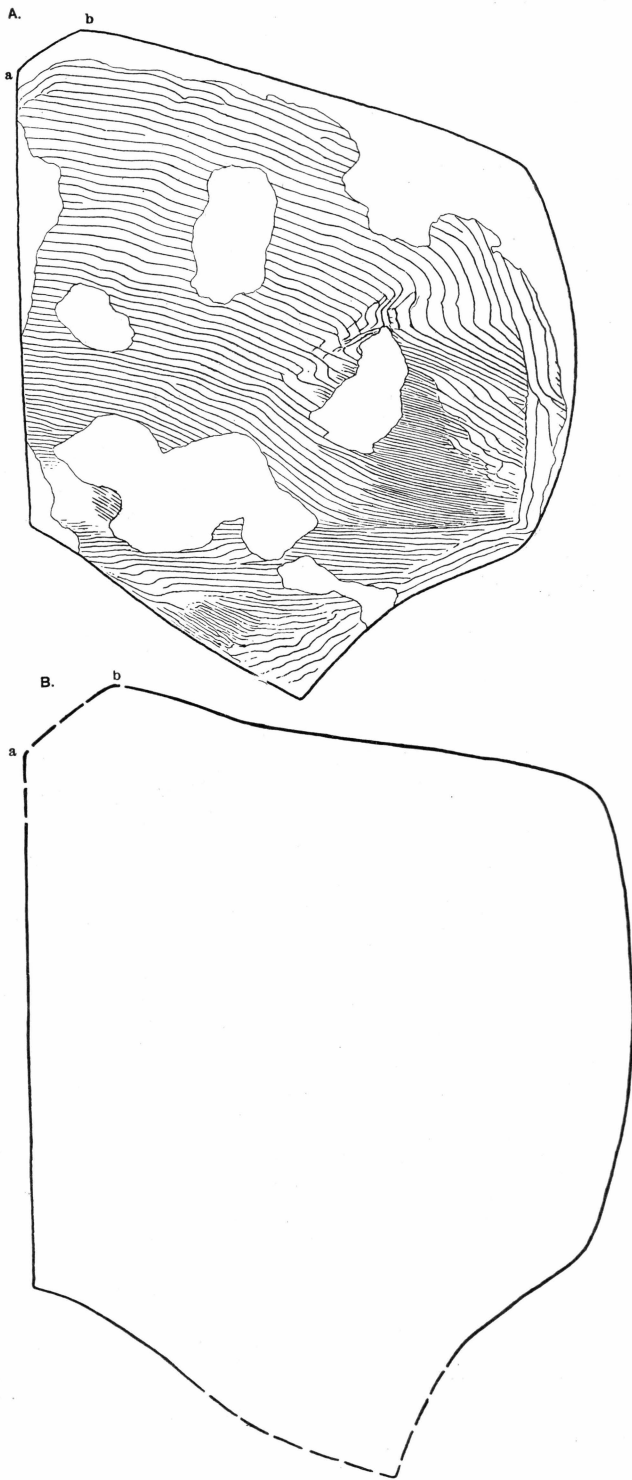


Text-fig. 21. *Phyllolepis orvini* HEINTZ. Intero-lateral plate. *A*, a left plate in anterior view (the plate in pl. 17 figs. 1, 2); *B*, same plate in ventral view; *C*, *D*, two rostro-caudal sections through the same plate at the planes 1 and 2 respectively; *E*, a right plate of a somewhat larger specimen (pl. 17, fig. 3). Anterior view. Slightly diminished. *f*, freely exposed part of the ventral face; *ovd*, area overlapped by the anterior ventro-lateral plate.

and breadth. How wide this range of variation may have been, it is still difficult or even impossible to ascertain.

In text-figs. 2, 4, 23, 24 attempted restorations are given of the armour of various individuals in its present flattened condition. In text-fig. 24 an attempt has been made to show the position of the ventral wall of the armour in its relation of the dorsal and lateral walls.

The superficial layer of the dermal plates is, as has already been

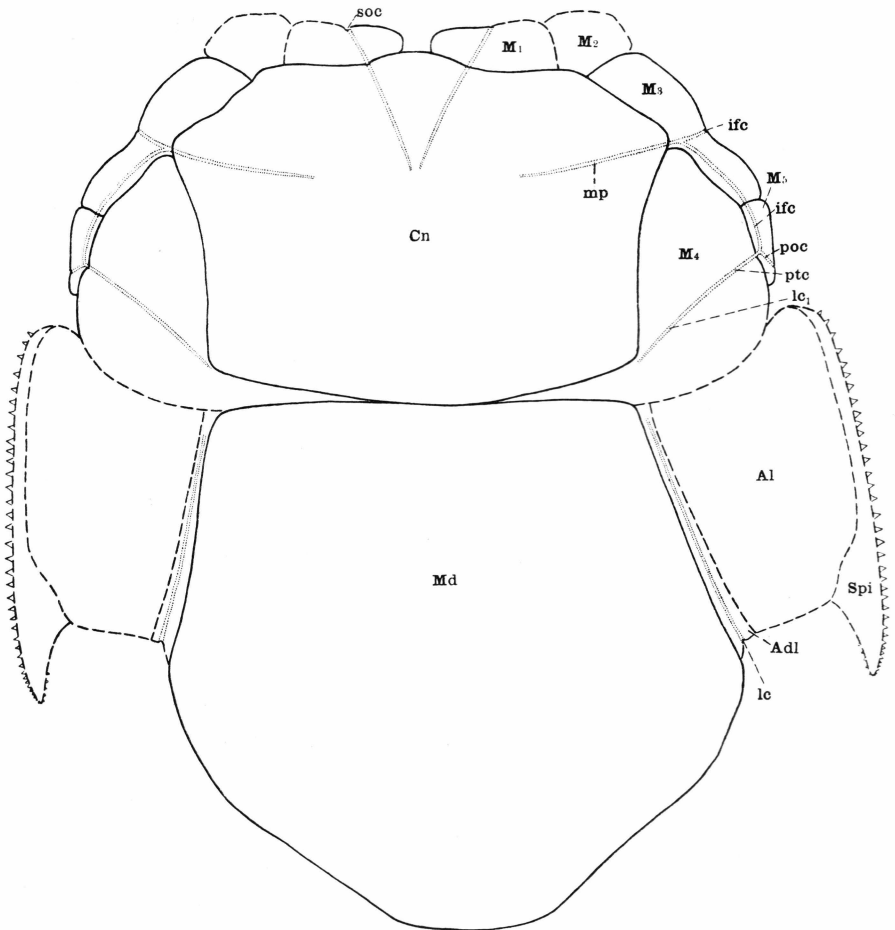


Text-fig. 22. *Phyllolepis orvini* HEINTZ. A, anterior ventro-lateral plate of the left side of the specimen in pl. 19. B, anterior ventro-lateral plate of the right side. Restoration after the plate shown in pl. 21. Cf. also text-figs. 4 and 24. One half of the nat. size. *a—b*, antero-medial margin, which is in contact with the anterior median ventral plate.

mentioned above (p. 19), generally slightly developed or absent except in certain cases on the lateral and ventral plates of the trunk armour, on which it may even be well developed (pls. 29, 30).

The sensory grooves are as a rule fairly well developed. At least as far as can be seen at present they show no characters of any specific importance.

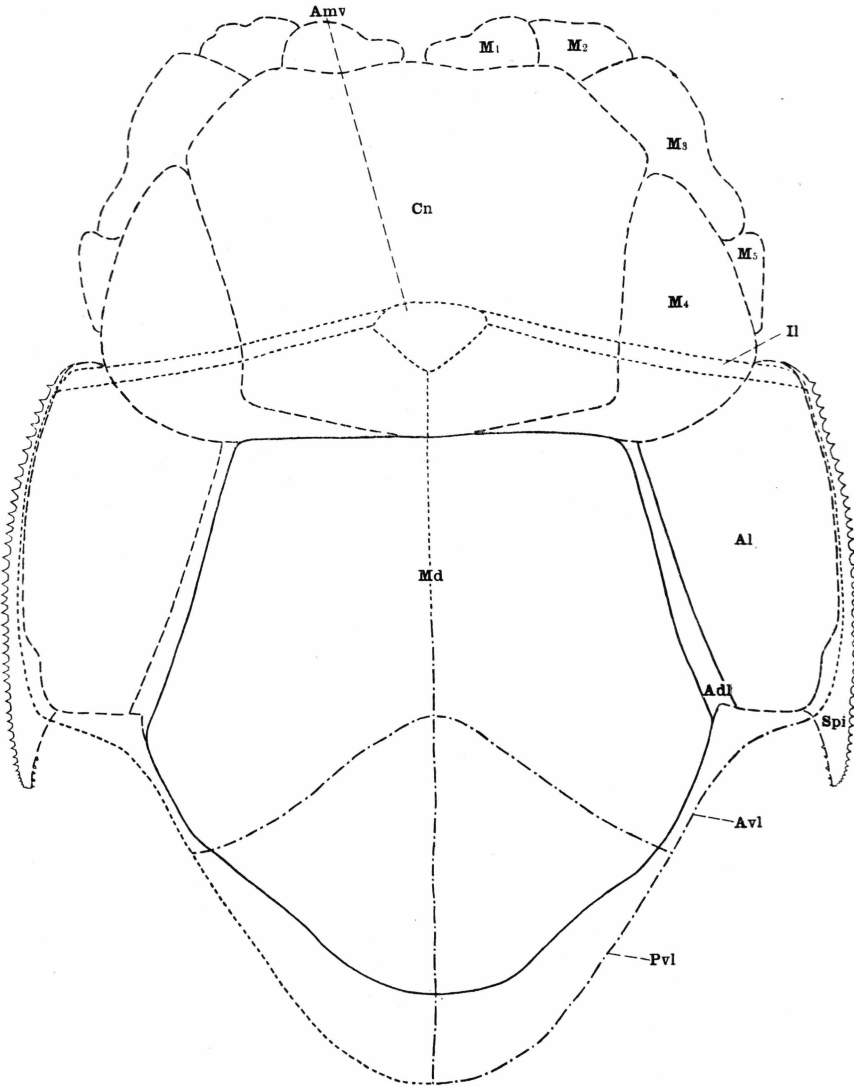
Remarks. — From the large new material at hand it is now evident



Text-fig. 23. *Phyllolepis orvini* HEINTZ. Attempted restoration of the flattened armour in dorsal view. Restoration made after the specimen figured in pl. 28 (no. 330d) in which the median cephalic plate and the median dorsal plate are fairly short and broad (cf. text-fig. 2). Much diminished. *Al*, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Cn*, median cephalic plate; *M*₁—*M*₅, marginal plates 1—5; *Md*, median dorsal plate; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *lc*, main lateral line; *lc*₁, cephalic division of the main lateral line; *mp*, probably middle pit-line; *poc*, preopercular sensory groove; *ptc*, postotic sensory groove; *soc*, supra-orbital sensory groove.

that *Phyllolepis söderberghi* STENSIÖ cannot be distinguished any longer from *Ph. orvini* HEINTZ, but that it must be united with that. As *Ph. orvini* HEINTZ has the priority to *Ph. söderberghi*, the latter species name must be dropped.

Among the *Phyllolepis* species described as yet *Ph. orvini* resembles



Text-fig. 24. *Phyllolepis orvini* HEINTZ. Attempted restoration of the flattened armour in dorsal view, with the position of the ventral wall in relation to it shown in broken lines (after the specimen shown in pl. 27). Much diminished. *Al*, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Amv*, anterior median ventral plate; *Avl*, anterior ventro-lateral plate; *Cn*, median cephalic plate; *Il*, inter-lateral plate; *M*₁—*M*₅, marginal plates 1—5; *Md*, median dorsal plate; *Pvl*, posterior ventro-lateral plate; *Spi*, spinal plate.

mostly *Ph. concentrica* (cf. text-figs. 3, 5, 8), differing from that species mainly only in its much larger size, in the relatively smaller length of its head armour and in the relatively somewhat smaller length of its median cephalic plate. From *Ph. undulata* it differs in its much larger size, in the relatively much smaller length of its head armour, in the probably relatively smaller length of its median cephalic plate and in its much stronger and coarser ornament. Accordingly it seems to be well defined as a species.

Geological horizon and localities. — The *Phyllolepis* series. Mt. Bothriolepis on Ymer Island; south side of Mt. Sederholm in Parallell Valley (several places); and Glacier Valley between Circus Mt. and Remigolepis Ridge (text-fig. 1).

(In 1934 material of *Phyllolepis* was described from the north-side of Mt. Sederholm (Vasti Valley), the south-side of Mt. Sederholm (several places) and the bottom of the western part of Parallel Valley on Gauss Peninsula, and from Cape Graah on Ymer Island.)

Euarthrodira.

General remarks.

Euarthrodire remains were for the first time described from the Upper Devonian of East Greenland by HEINTZ in 1932 (1932a, pp. 18—24). These remains appeared to belong to a new genus *Groenlandaspis* and a new species *G. mirabilis*.

HEINTZ was able to show that *G. mirabilis* in several characters, as for instance the construction of the posterior part of the dermal cranial roof, the development and position of the joint between the cranial roof and the trunk armour, and the shape of the median dorsal plate is suggestive of certain Acanthaspids such as *Jaekelaspis*. It differs, however, in certain other characters so much from the Acanthaspids that HEINTZ considered it unlikely that it was more closely allied to them.

The material of Euarthrodires brought home by the Danish East Greenland expeditions is small, consisting only of an imperfect plate described by the writer in 1934 (STENSIÖ 1934a, p. 55) and of a few detached plates, which will be described in the present paper. Whether it is referable to *Groenlandaspis* or another genus or to both that and another genus is very difficult to make sure¹⁾.

During the last Danish expeditions it has been established that

¹⁾ Dr. A. HEINTZ whom I have asked of his opinion in this matter has kindly informed me that he is also uncertain whether anything of the material belongs to *Groenlandaspis*.

Euarthrodires in East Greenland are found only in the uppermost division of the Upper Devonian — the Arthrodire sandstone series (cf. SÄVE-SÖDERBERGH 1934 a, pp. 43—46; 1935; KOCH 1935, pp. 53—57) —, which is the youngest Upper Devonian in Old Red facies known as yet in any detail.

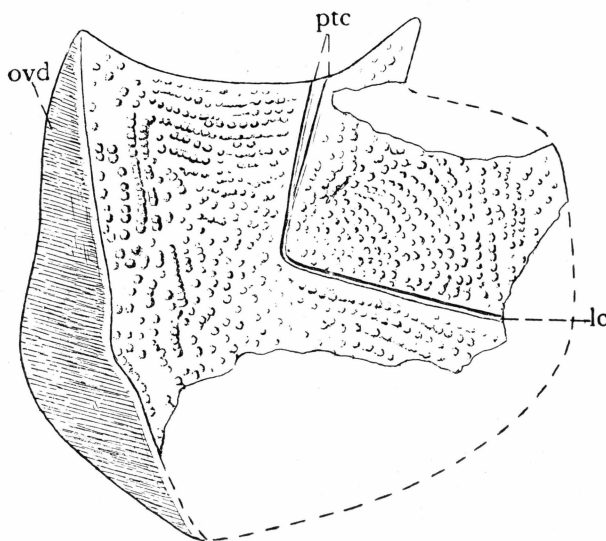
The Upper Devonian Euarthrodires from East Greenland are thus, as we find, the latest representatives of their group known as yet¹⁾, and they are therefore of so much interest that it is to be hoped that new and better finds will be made during the expedition which is planned already for next summer.

Description of the new Greenland material.

Euarthrodires remains not nearer determinable as to genus and species.

(Text-figs. 25, 26; pl. 1, fig. 7; pl. 14, fig. 1; pl. 18, fig. 1).

Material. — The whole new material available comprises only a few imperfectly preserved plates (nos. 976—980), of which two are from the head, whereas the other are from the trunk. Of the two plates



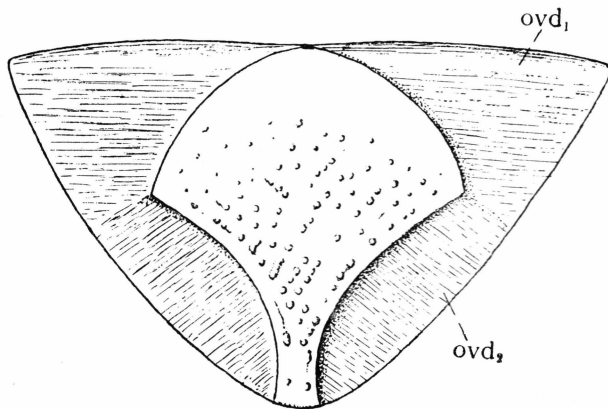
Text-fig. 25. Euarthrodire, not nearer determinable. Supposed right paranuchal plate (externo-basal) in dorsal view. Restored after the specimen in pl. 18, fig. 1. Nat. size. *lc*, cephalic division of the main lateral line; *ovd*, overlapped area along the medial margin; *ptc*, postotic groove.

¹⁾ *Cratoselache*, which is from the Lower Carboniferous, has in the present work been placed in the *Placodermi* (cf. above pp. 28—31) and if this opinion of its position is true, other groups of the *Placodermi* would thus have survived into the Carboniferous.

of the head one is probably a right paranuchal, whereas the other one is indeterminable.

Description. — All the plates present are from at least somewhat large individuals.

The supposed right paranuchal (externo-basal (text-fig. 25; pl. 18, fig. 1)) is a thick, strong paired plate. Along its supposed medial margin it has a broad overlapped area. The margin which is supposed to be the anterior one has a fairly pronounced antero-lateral process, medially to which it is concave. The lateral margin was probably fairly short. The supposed posterior margin seems to have been long and to have been directed only slightly laterally. The plate bears a sensory groove, which forms a sharp medial bend in a somewhat similar way as in certain Acan-



Text-fig. 26. Euarthrodire, not nearer determinable. A median ventral plate (probably the anterior one). Ventral view. Restored after the specimen shown in pl. 14, fig. 1. Nat. size. *ovd*₁, *ovd*₂, overlapped areas (the former probably for the intero-lateral plate, the latter probably for the anterior ventro-lateral plate).

thaspids such as *Svalbardaspis* (HEINTZ 1929a, pl. 19, fig. 2). The anterior portion of that sensory groove, which is probably to be considered as a postotic groove, is double. The whole groove, which is widest at the bottom, opens outwards with a narrow slit only. The ornament consists of rounded, low tubercles, disposed somewhat concentrically with the margins of the plate.

Of the trunk armour only one plate, which may be either the anterior or posterior median ventral plate, is completely preserved. This plate (text-fig. 26; *Amv*, pl. 14, fig. 1) is broad, almost triangular in shape and has broad overlapped areas (*ovd*₁, *ovd*₂). Its exposed area is ornamented with fairly scattered, low, rounded tubercles. Comparisons with *Holonema* (OBRUTSCHEW 1933, text-figs. 2, 3) and Acanthaspids

(GROSS 1933, Abb. 7) seem to indicate that the plate most probably is an anterior median ventral plate.

A fragment of a paired plate found connected with the median plate described just above must be either of the right anterior ventro-lateral plate or of the left posterior ventro-lateral plate (*Avl*, pl. 14, fig. 1). The fragment is ornamented in a similar way as the median plate.

In pl. 1, fig. 7, a piece of a plate is shown, which, judging from its general characters and the presence of a sensory groove, probably may be either of an anterior or of a posterior dorso-lateral plate.

Remarks. — The supposed paranuchal (externo-basal) plate cannot be compared to the similarly termed plate in *Groenlandaspis*, as that is too imperfectly known. The supposed anterior median ventral plate seems to be both shorter than and of a different shape from that in *Groenlandaspis* (cf. HEINTZ 1932a, text-fig. 12).

Under such conditions I have found it most appropriate not to refer anything of the material here described to *Groenlandaspis*.

In this connection it should be mentioned that Dr. HEINTZ, Oslo, whom I have sent photos of the bone-plates considered by me to be the paranuchal (externo-basal) and anterior median ventral plates, kindly informs me that he thinks my interpretations of these two plates is the most plausible one. I wish here to thank Dr. HEINTZ most cordially for the great help he has given me in checking my determination in this case.

Geological horizon and locality. — The Arthrodire sandstone series. West side of Mt. La Cour towards the Gästis Valley, Gauss Peninsula.

(The material described in 1934 is from the Arthrodire sandstone series in Mt. Stensiö on Gaus Peninsula, whereas the material dealt with by HEINTZ comes from Mt. Celsius on the Ymer Island).

Summary.

From the detailed knowledge now gained of it it is clear that *Phyllolepis* agrees with the Arthrodires in the following characters. 1) The presence of a heavy armour on both the head and trunk; 2) the reduction of the pectoral fin into an immovable spine; 3) the general arrangement of the plates in the dermal cranial roof; 4) the general arrangement of the plates in the trunk armour; 5) the shape of several of the plates in the trunk armour; 6) the microscopic structure of the dermal bones; and 7) the development and general pattern of the sensory

groove system. It is therefore beyond question that *Phyllolepis* is so closely allied to the Arthrodires that it must be placed with them. On the other hand, as it differs from the Euarthrodires [*Acanthaspida*, *Brachytoraci*, (*Coccosteida*) and *Ptychodontida*] in the presence of a large median cephalic plate, probably representing both the median nuchal plate (median basal) and the central plates of the Euarthrodires, in the presence of a long sensory groove, probably representing the short middle head-line of fishes in general, in the tendency of the sensory canal system of forming sharp loops, in the strong reduction or perhaps even absence of the posterior median ventral plate, and in the much reduced state of the head and trunk armour on the whole, it cannot be referred to these but must be placed in a group of its own.

Accordingly the Arthrodira would at present comprise two main groups: the *Euarthrodirea* and the *Phyllolepida*.

In connection with the discussion of the relationships of *Phyllolepis* the conception of the *Placodermi* as a whole has also been dealt with. The *Stegocelachii* and *Rhenanida* have now also been placed in the *Placodermi*.

Finally a brief description of a few fragmentarily remains of Euarthrodires has also been given.

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EXPLANATION OF PLATES

The material described and figured belongs to the Geological Survey of Greenland.

The macro photos have been taken with Zeiss Tessar objectives F. 36 cm and F. 25 cm. The plate sort used was Ilfords "Special rapid panchromatic".

Plate 1.

- Figs. 1, 2. *Phyllolepis orvini* HEINTZ. Marginal plate 1. Fig. 1 of the left and fig. 2 of the right side of the specimen figured in pl. 25. Specimen no. 330a. Nat. size.
- Fig. 3. *Phyllolepis orvini* HEINTZ. Marginal plate 1 of the right side of the specimen figured in pl. 9. Specimen no. 330f. Nat. size.
- Figs. 4, 5. *Phyllolepis orvini* HEINTZ. Marginal plate 5. Fig. 4 of the specimen figured in pl. 28. Specimen no. 330d. Fig. 5 of the specimen figured in pl. 25. Specimen no. 330 a. Nat. size.
- Fig. 6. *Phyllolepis orvini* HEINTZ. Impression of the anterior area of a left intero-lateral plate and af a part of a left marginal plate 5. Specimen no. 351b. Nat. size.
- Fig. 7. *Enarthrodire*, fragment probably of the anterior or posterior dorso-lateral plate. Specimen no. 976. Nat. size.

Il, intero-lateral plate; *M*₅, marginal plate 5 (only a part is exposed); *ifc*, infraorbital sensory groove; *ovd*, overlapped area; *poc*, preopercular sensory groove; *ptc*, postotic sensory groove; *soc*, supraorbital sensory groove.

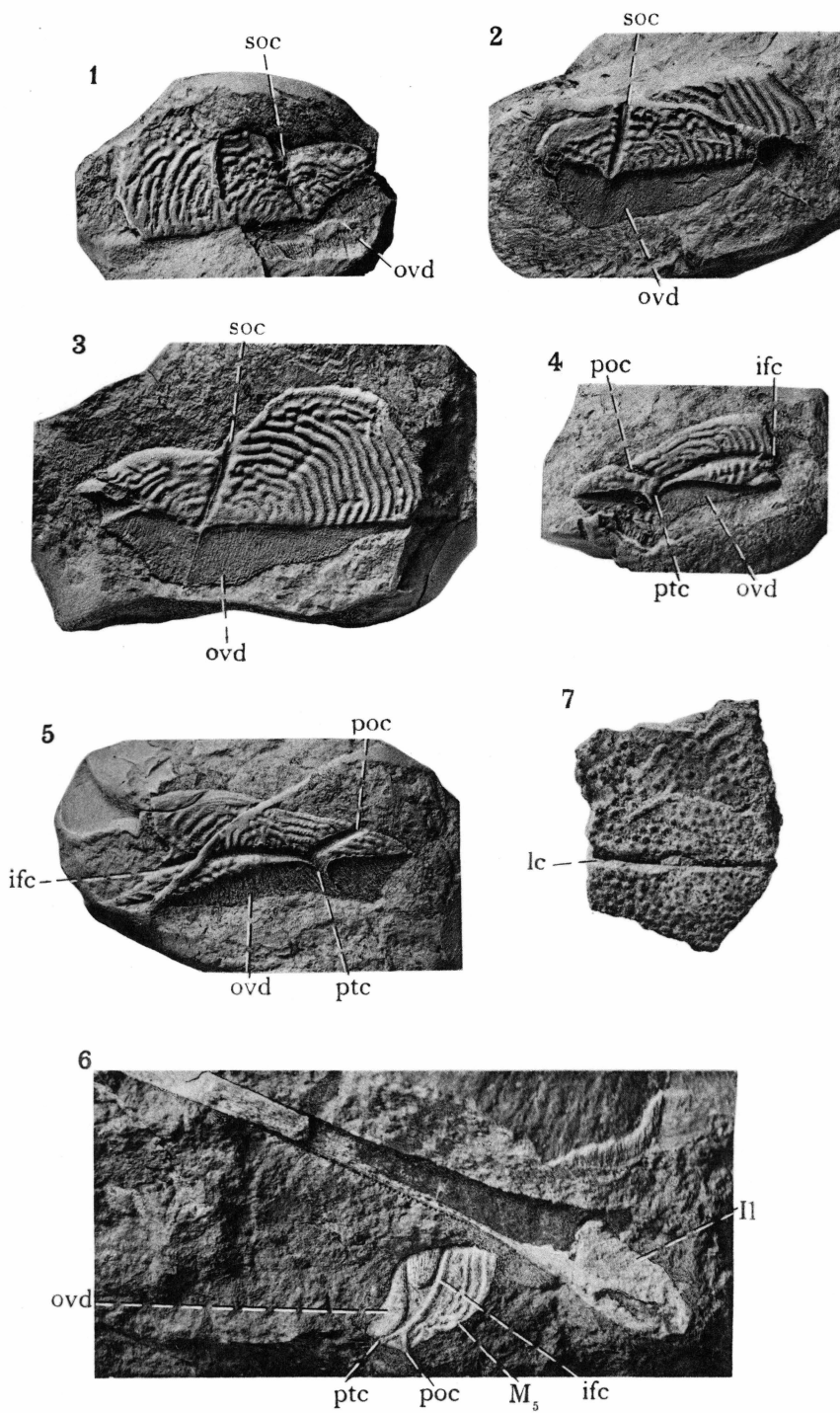


Plate 2.

Phyllolepis orvini HEINTZ.

Fig. 1. Median cephalic plate. Impression of dorsal face. Specimen no. 335. Nat. size.

Fig. 2. Marginal plates 2, 3, 4 and possibly also 5 preserved mainly as impressions. Specimen n. 336. Nat. size.

M_2 , M_3 , M_4 , marginal plates 2—4; M_5 , possibly part of the marginal plate 5; *ifc*, infraorbital sensory groove; *ifc.b*, posteromedial branch of the infraorbital sensory groove (part only developed), lc_1 , cephalic division of the main lateral line; *mp*, middle pit-line (double in fig. 1); *ovd*, overlapped area; *ovd*₁, area overlapped by the median cephalic plate; *ovd*₂, area overlapped by the marginal plate 4; *soc*, supra-orbital groove.

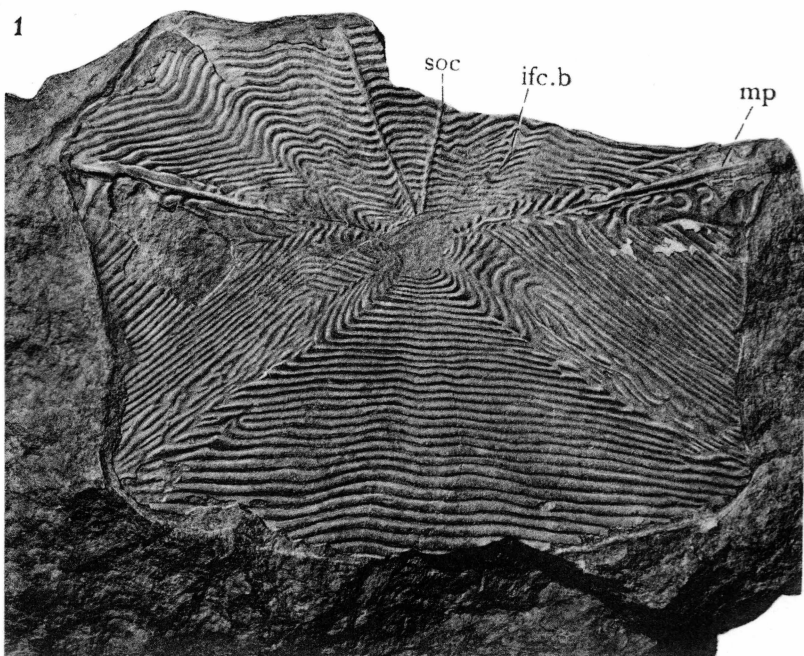
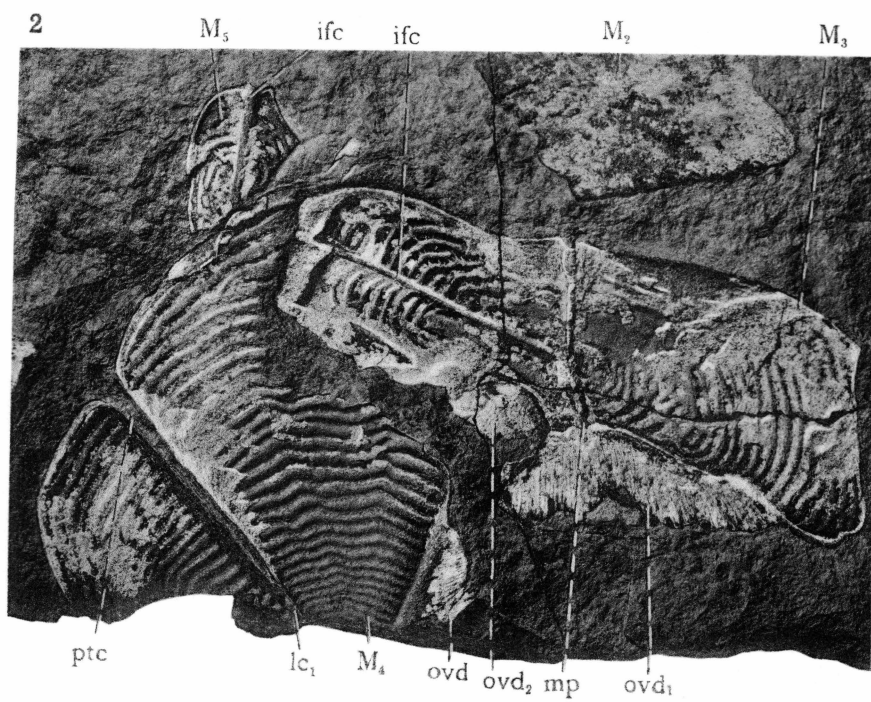


Plate 3.

Phyllolepis orvini.

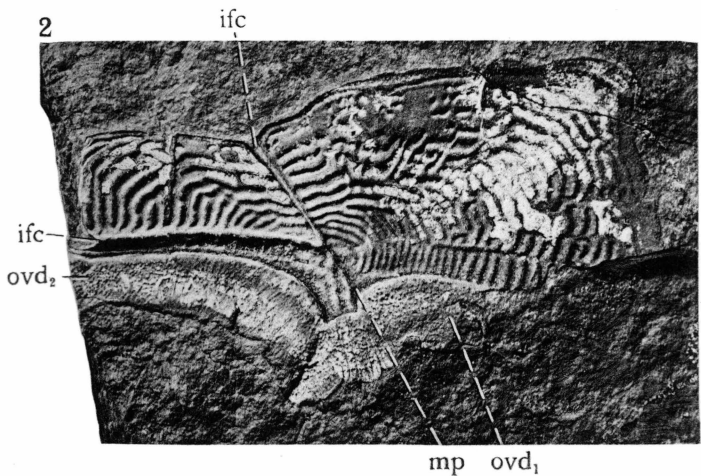
Figs. 1—3. Marginal plate 3. Fig. 1, impression of the lower side. Specimen no 337a; figs. 2, 3, impressions of the upper (external) side. Specimens nos. 338 and 337b (counter part of the specimen in fig. 1) respectively. Nat. size.

ifc, infraorbital sensory groove; *mp*, middle pit-line; *ov*, area overlapping the marginal plate 2; *ovd*₁, area overlapped by the median cephalic plate; *ovd*₂, area overlapped by the marginal plate 4.

1



2



3

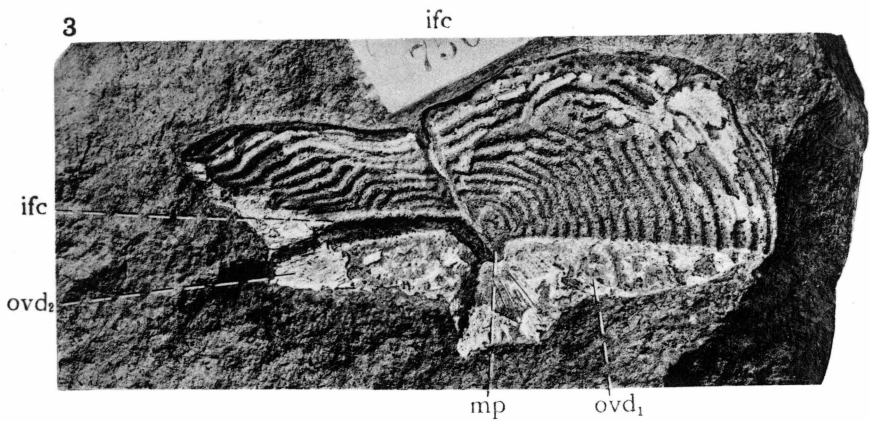


Plate 4.

Phyllolepis orvini HEINTZ.

Fig. 1. Marginal plate 4 (right) preserved as impression of the dorsal side. Specimen no. 351a. Nat. size.

Fig. 2. Marginal plate 4 (right) preserved mainly as impression of the dorsal side and showing the posterior continuation of the cephalic divisions of the main lateral line. Specimen no 332. Nat. size.

*lc*₁, cephalic division of the main lateral line; *ovd*, overlapped area; *ptc*, postotic sensory groove.

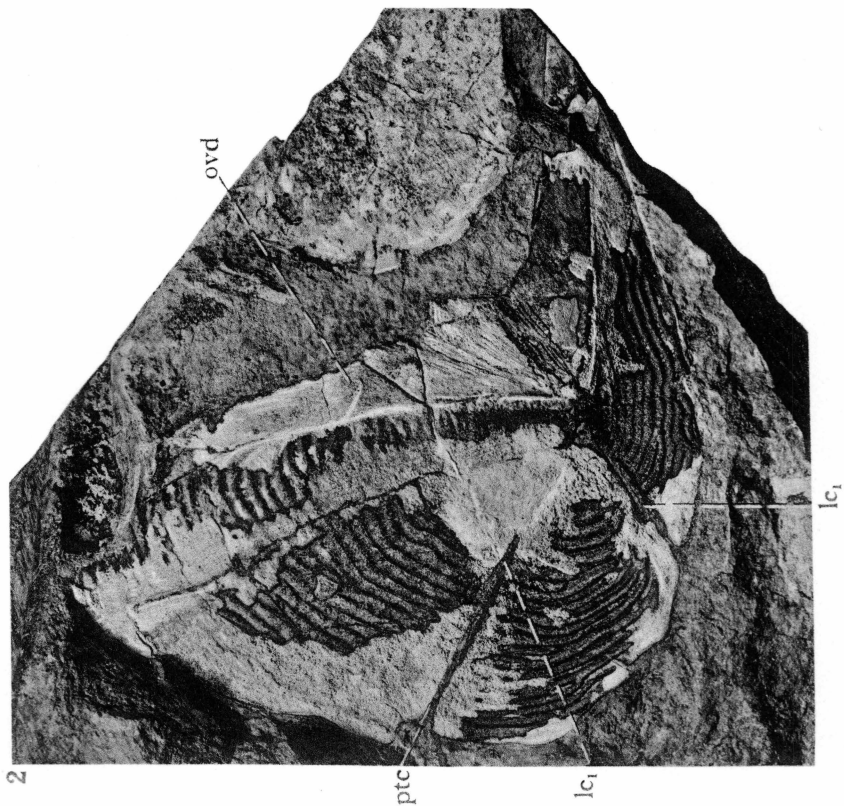
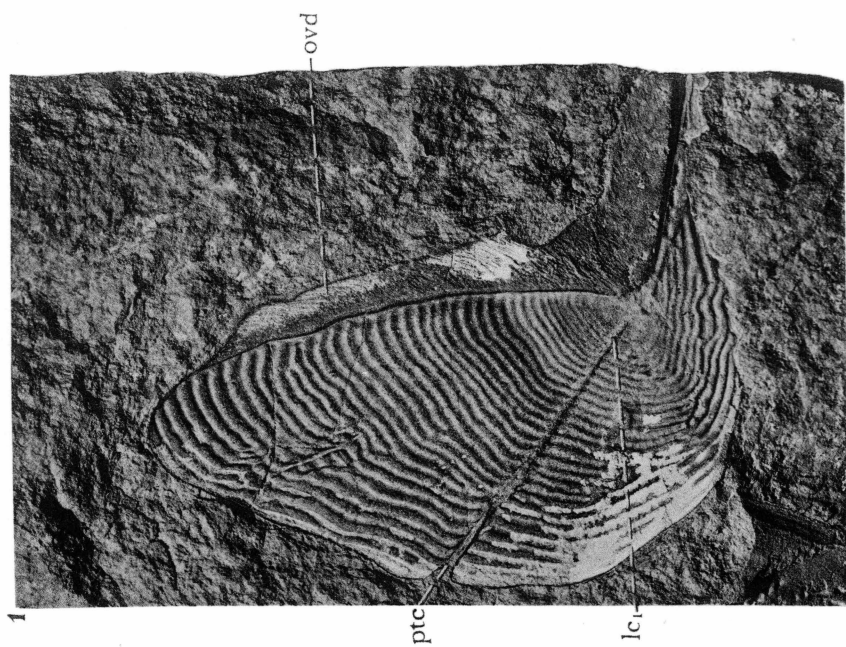


Plate 5.

Pyllolepis orvini HEINTZ.

Median cephalic plate preserved as impression of the lower side. The overlapping areas partly well shown. Specimen no. 331. Nat. size.

gr, median groove; *ov*₁, area overlapping the marginal plate 1; *ov*₂, area overlapping the marginal plate 2; *ov*₃, area overlapping the marginal plate 3; *ov*₄, area overlapping the marginal plate 4.



Plate 6.

Phyllolepis orvini HEINTZ.

Fig. 1. Marginal plate 4 (right). Impression of the anterior part of the ventral face with the overlapping areas. Specimen no 351b. Nat. size.

Fig. 2. Part of the median cephalic plate preserved mainly as impression of the dorsal face. The sensory groove *pp* is well shown.

mp, groove probably representing the middle pit-line of the Euarthrodiros: *ov*₁, area overlapping the posterior part of the marginal plate 3; *ov*₂, area overlapping the marginal plate 5; *pp*, groove probably corresponding to the posterior pit-line of fishes in general.

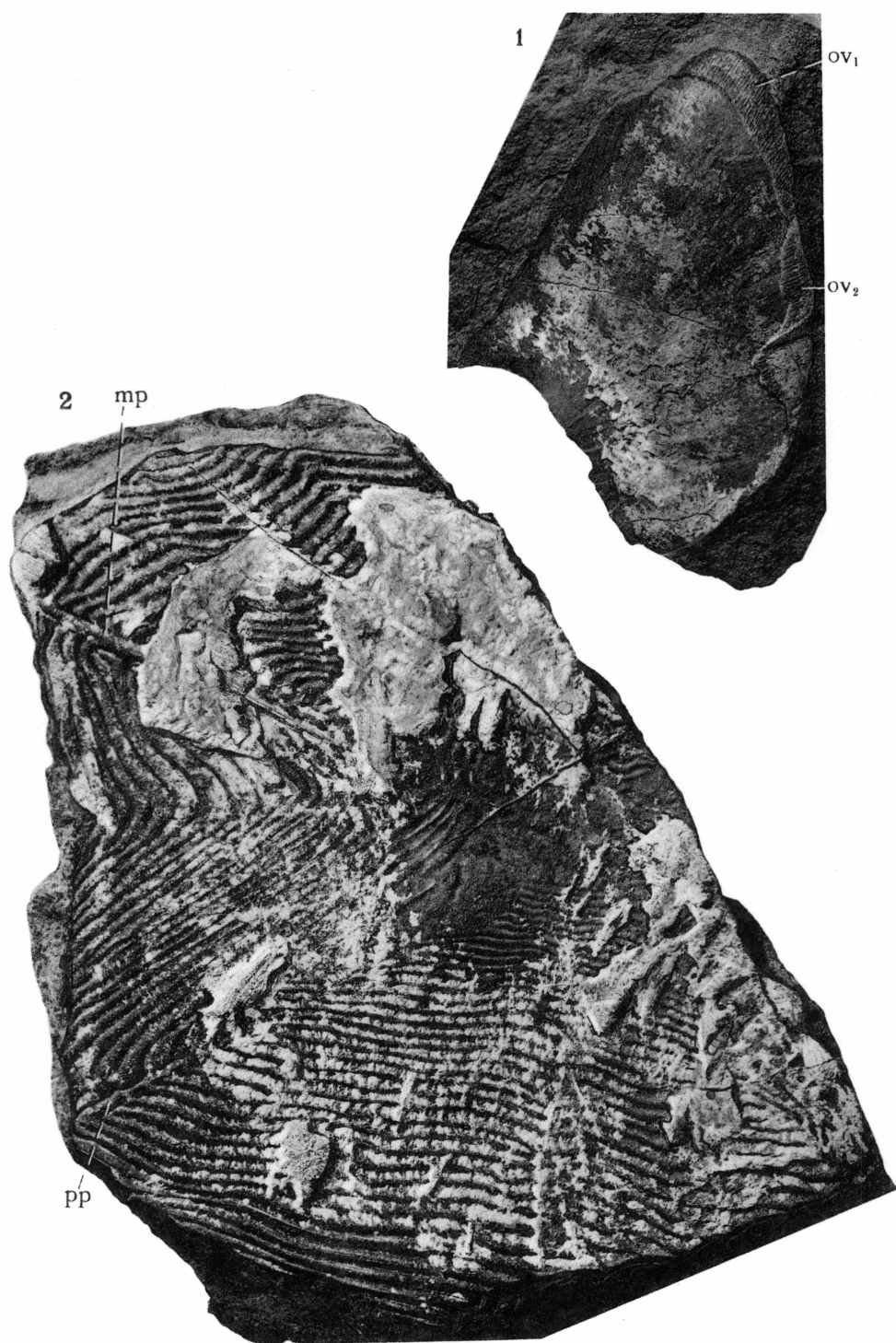


Plate 7.

Phyllolepis orvini HEINTZ.

Fractured cephalic plate preserved as impression of the external (dorsal) side. Specimen no. 342. Slightly diminished.

ifc.b, probably a vestige of the postero-medial branch of the infraorbital sensory groove; *mp*, groove, probably representing the middle pit-line of the Euarthrodiros; *soc*, supraorbital sensory groove.



Plate 8.

Phyllolepis orvini HEINTZ.

Imperfect median cephalic plate preserved partly as impression of the external (dorsal) side. Specimen no. 330e. Approximately $\frac{2}{3}$ of the nat. size.

Cn, median cephalic plate; *M*₄, marginal plate 4; *ifc.b*, postero-medial branch of the infraorbital groove; *mp*, groove probably representing the middle pit-line of the Euarthrodiros; *soc*, supraorbital groove.



Plate 9.

Phyllolepis orvini HEINTZ.

A median cephalic plate associated with several of the marginal plates of the same individual. The plates in part preserved as impressions of the external (dorsal) side. Specimen no 330f. Approximately $\frac{3}{4}$ of the nat. size.

Arc, arcual elements; *Cn*, median cephalic plate; *M*₁, marginal plate 1 (only a part shown); *M*₂—*M*₅, marginal plates 2—5; *ifc*, infraorbital sensory groove; *ifc.b*, postero-medial branch of the infraorbital sensory groove; *mp*, groove probably representing the middle pit-line of the Euarthrodiros; *soc*, supraorbital groove.

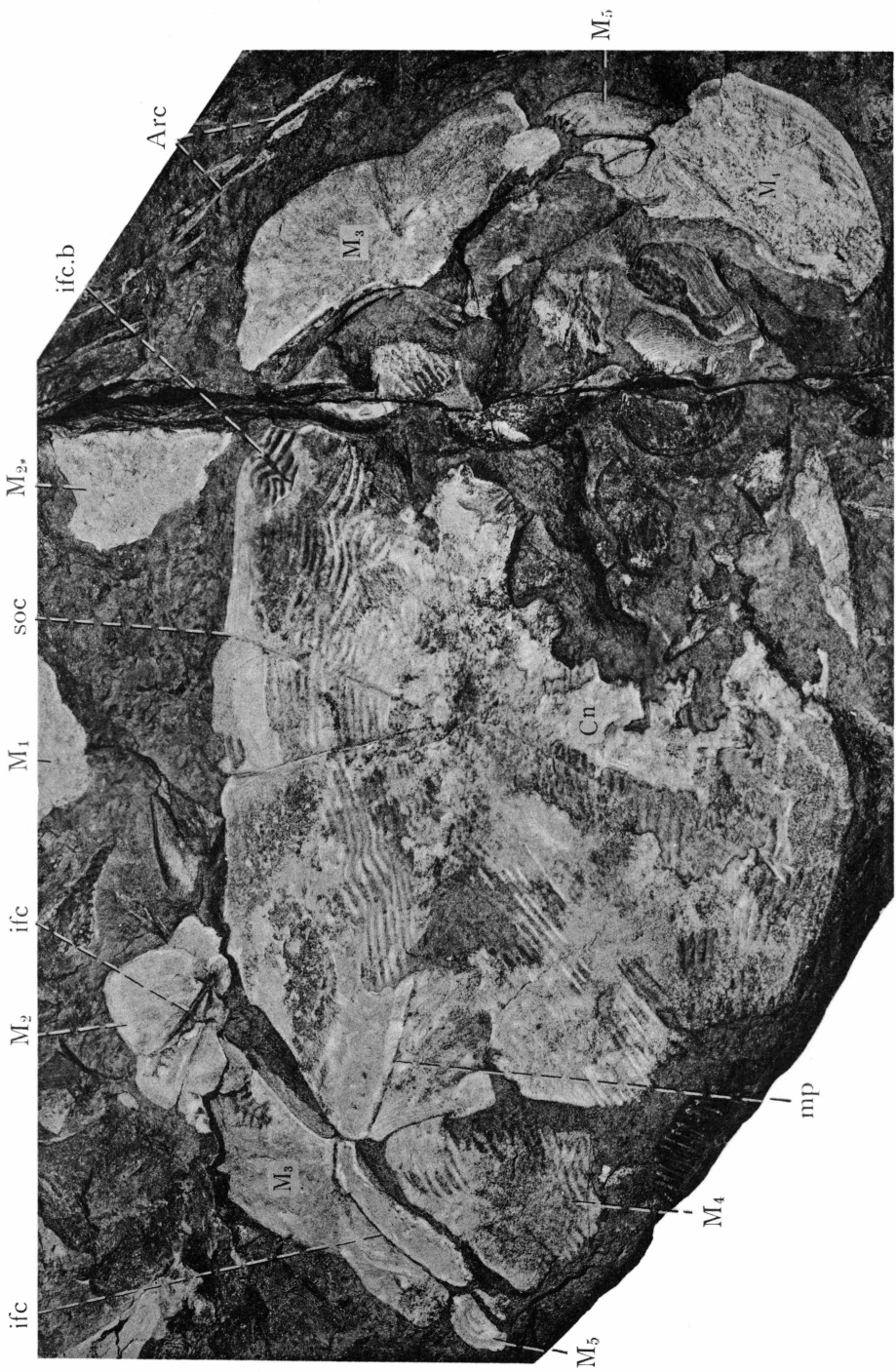


Plate 10.

Imperfect median dorsal plate preserved mainly as impression of the external (dorsal) side. Specimen no. 348 Approximately $\frac{2}{3}$ of the nat. size

ld, groove probably representing the dorsal lateral line; *dx*, median unpaired groove probably belonging to the sensory canal system

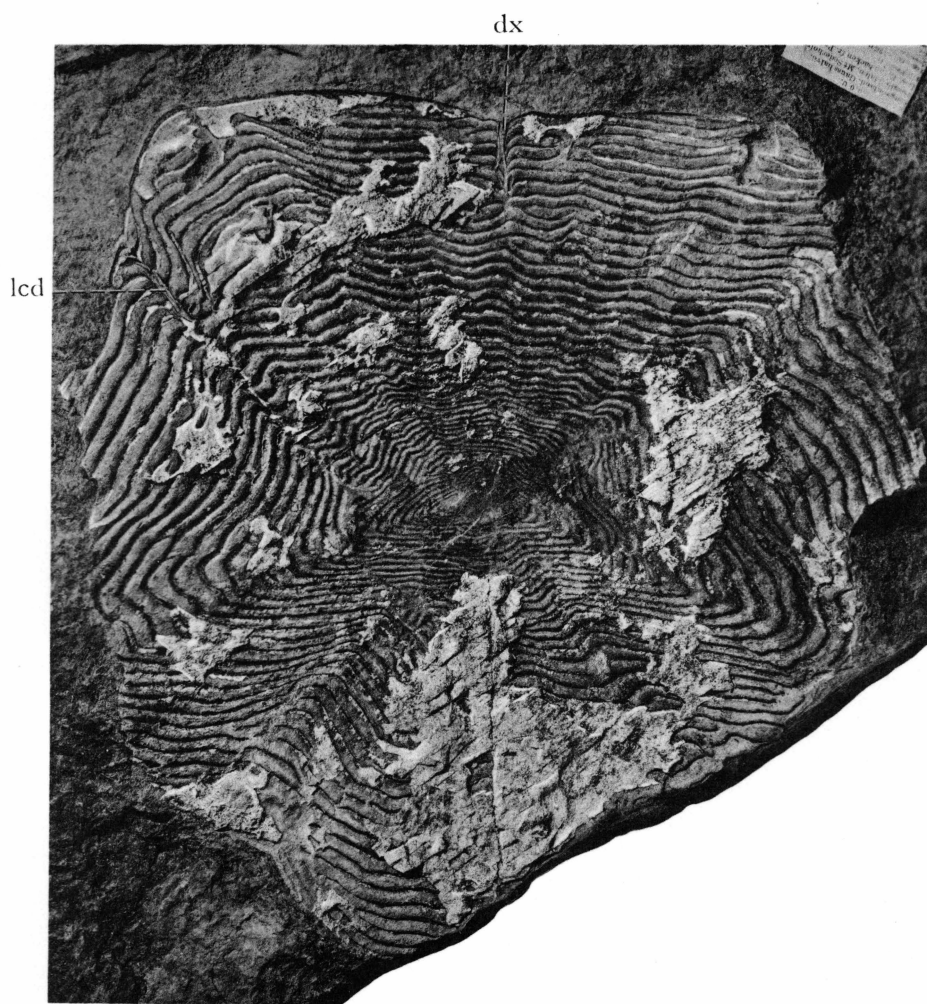


Plate 11.

Phyllolepis orvini HEINTZ

Median dorsal plate preserved mainly as impression of the external (dorsal) side. Specimen no. 333. Approximately $\frac{2}{3}$ of the nat. size.



Plate 12.

Phyllolepis orvini HEINTZ.

Median dorsal plate preserved as impression of the external (dorsal) side.
Specimen no. 344. Approximately $\frac{3}{4}$ of the nat. size.



Plate 13.

Phyllolepis orvini HEINTZ.

Part of a median dorsal plate preserved as impression of the external (dorsal) side. Specimen no. 341. Nat. size.



Plate 14.

- Fig. 1. *Euarthrodire* gen. et spec. indet. A median ventral plate probably the anterior one in ventral view. Associated with it a part of a paired plate, probably the right anterior ventro-lateral plate. Specimen no. 978. Nat. size.
- Fig. 2. *Phyllolepis orvini* HEINTZ. Anterior part of a right anterior dorso-lateral plate preserved in the main as impression of the external (dorso-lateral) side. Specimen no. 344. Nat. size.

Adl, anterior dorso-lateral plate; *Amv*, probably the anterior median ventral plate; *Avl*, a part probably of the right anterior ventro-lateral plate (anterior part). *Md*, median dorsal plate (small part only); *a*, anterior face; *lc*, main lateral line; *ovd*₁, *ovd*₂, overlapped areas; *pr*, *pr*₁, dorsal and ventral process respectively of the anterior dorso-lateral plate.

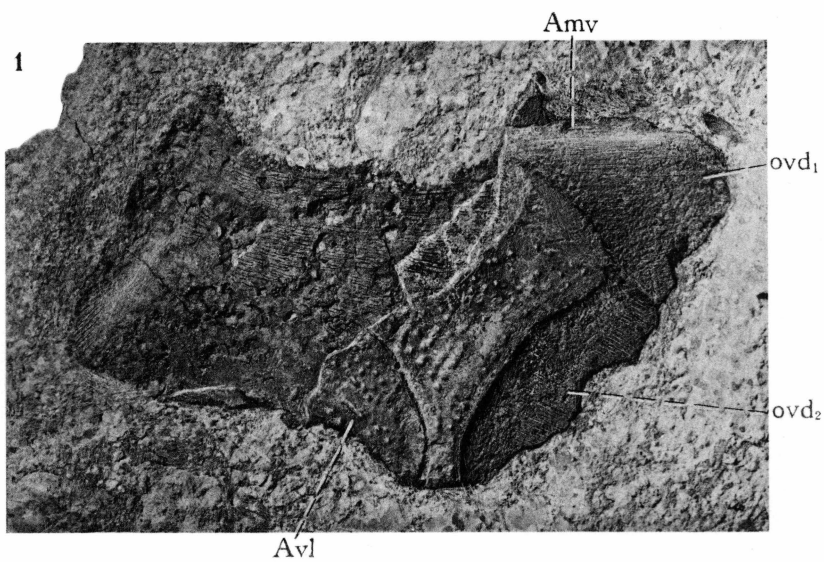
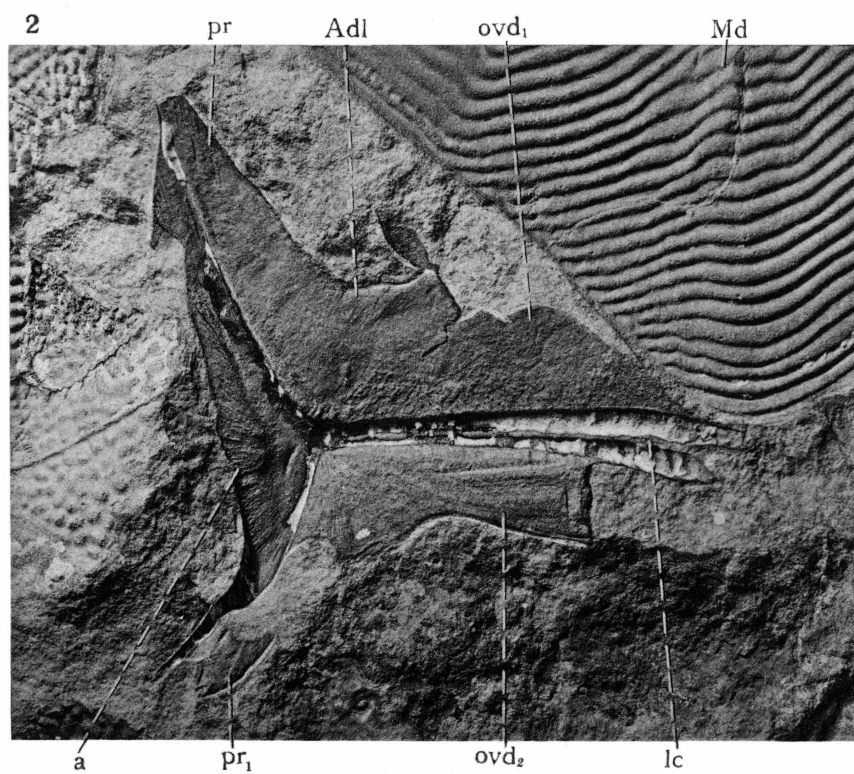


Plate 15.

Phyllolepis orvini HEINTZ.

Figs. 1, 2. Anterior lateral plate. Impression of the medial (internal) side. The plate in fig. 1 lacking a part both anteriorly and posteriorly. Fig. 1, specimen no. 345, Fig. 2, specimen no. 439a (from the earlier collection).

a—b, stretch of the anterior margin, that probably was in contact with the intero-lateral plate; *ov*, area overlapping the anterior dorso-lateral plate; *ov*₁, area overlapping the spinal plate; *r*, ridge bounding the area *ov*.

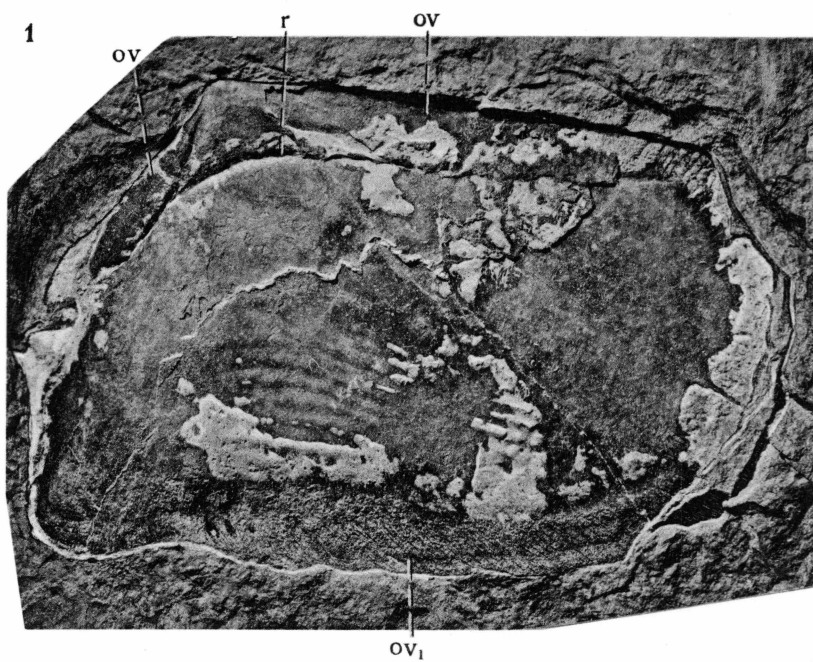
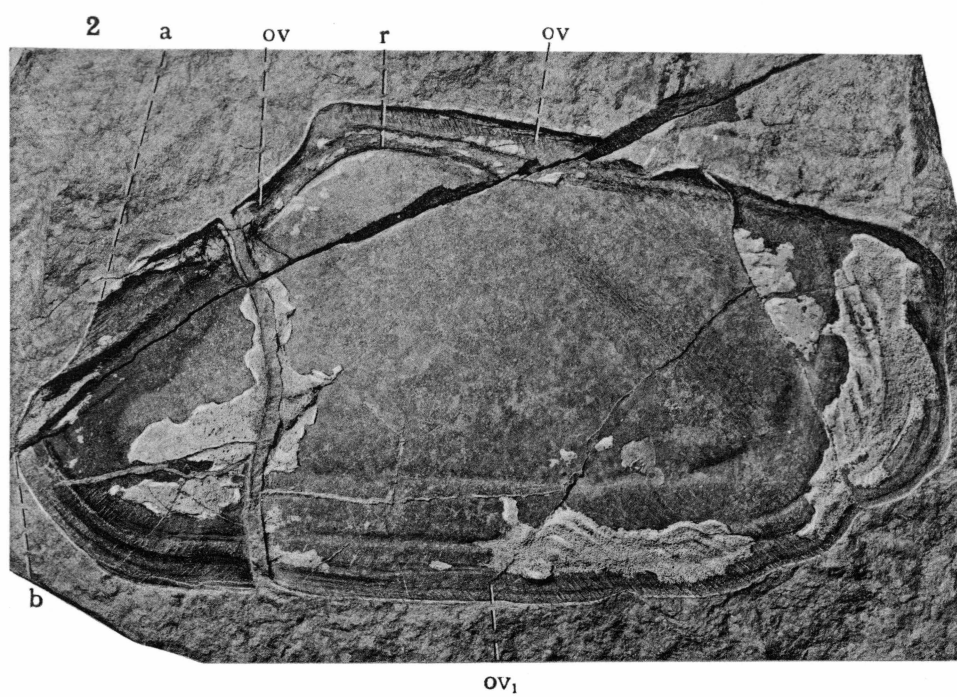
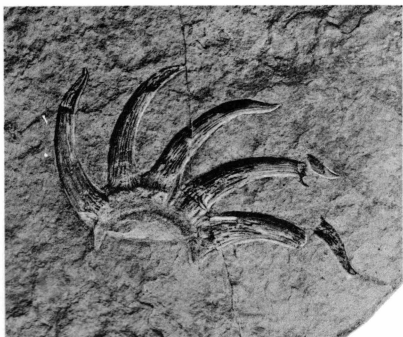


Plate 16.

Figs. 1, 2. *Onychodus* sp. The only specimen found as yet in the upper Devonian of East Greenland. Specimen no. 343a—b. Nat. size.

Figs. 3, 4. *Phyllolepis orvini* HEINTZ. Spinal plate (left). Fig. 3 impression of the dorsal side; fig. 4 the anterior two thirds in ventral view. Specimen no. 339a—b. Nat. size.

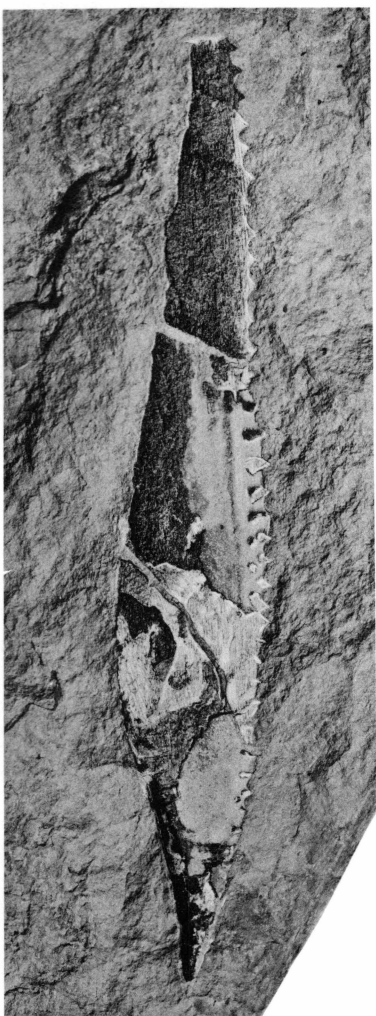
1



2



3



4



Plate 17.

Phyllolepis orvini HEINTZ.

- Fig. 1. Part of the ventral face of a left intero-lateral plate preserved as impression. The overlapped area (*ovd*) and the ornamented area (*f*) well shown. Specimen no. 351b (same as in pl. 1, fig. 6). Nat. size.
- Fig. 2. Dorsal lamina of the same intero-lateral plate as in fig. 1 and as in pl. 1, fig. 6. Partly in posterior view, partly as impression of the anterior face. Specimen no. 351a.
- Fig. 3. Right intero-lateral plate in anterior view. Specimen no. 342. Nat. size.
- Fig. 4. Anterior part of a left anterior dorso-lateral plate. Specimen no. 351a. Nat. size.

a, anterior face of the anterior dorso-lateral plate; *f*, ornamented free area; *lc*, main lateral line; *ovd*, area overlapped by the anterior ventro-lateral plate; *ovd*₁, area overlapped by the median dorsal plate; *ovd*₂, area overlapped by the anterior lateral plate; *pr*, *pr*₁, dorsal and ventral process respectively of the anterior dorso-lateral plate.

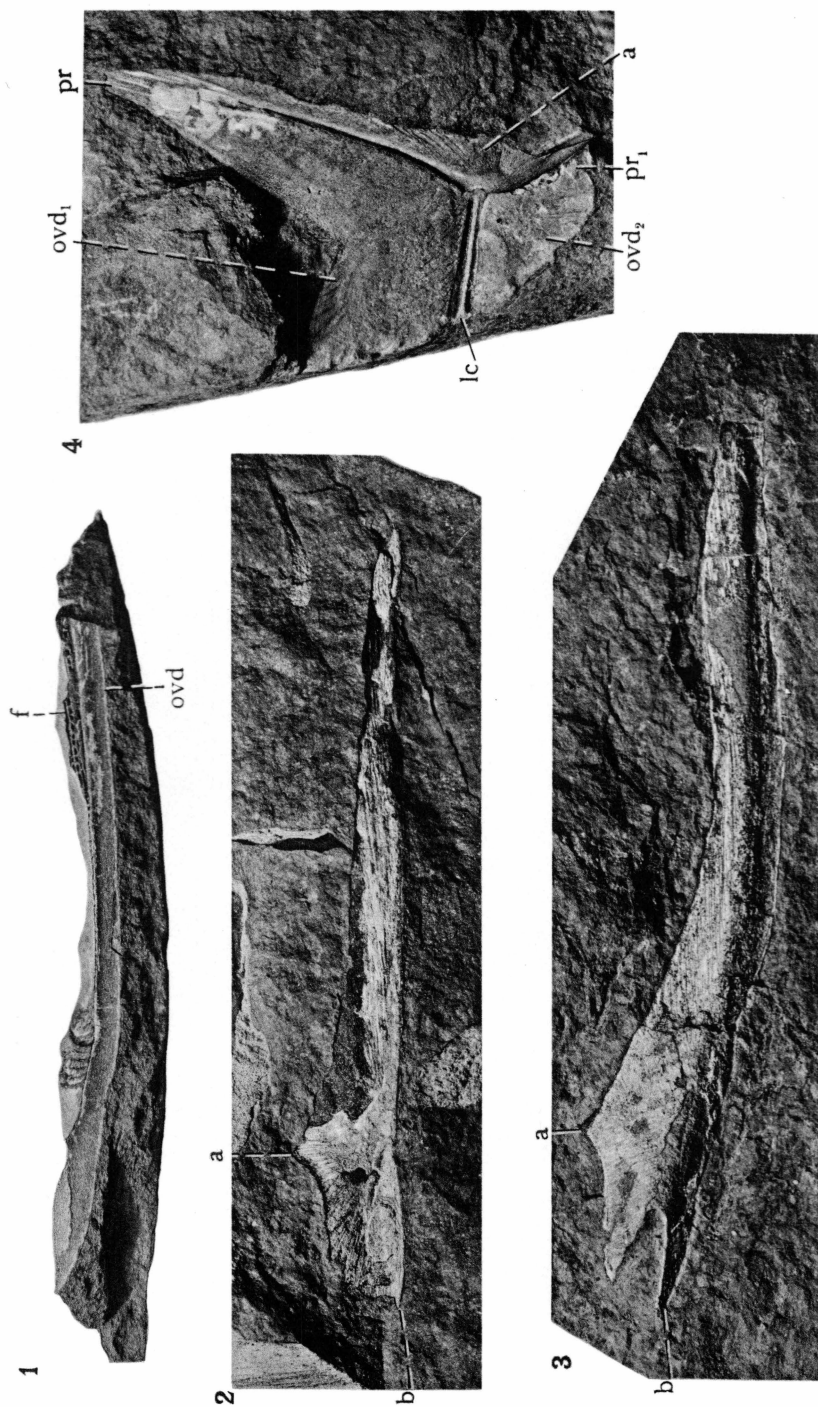


Plate 18.

Fig. 1. *Enarthrodire* gen. et spec. indet. Probably a right lateral nuchal plate. The plate preserved mainly as impression of its external (dorsal) side. Specimen no. 977. Nat. size.

Fig. 2. *Phyllolepis orvini* HEINTZ. An imperfect posterior ventro-lateral plate (left) and a likewise imperfect anterior dorso-lateral plate (left). Impressions of the external sides. Specimen no. 349. Nat. size.

Adl, anterior dorso-lateral plate; *Pvl*, posterior ventro-lateral plate; *lc*, main lateral line; *lc*₁, cephalic division of the main lateral line groove; *ovd*, area overlapped probably by the median nuchal plate; *ovd*₁, area overlapped by the median dorsal plate; *ptc*, probably postotic groove.

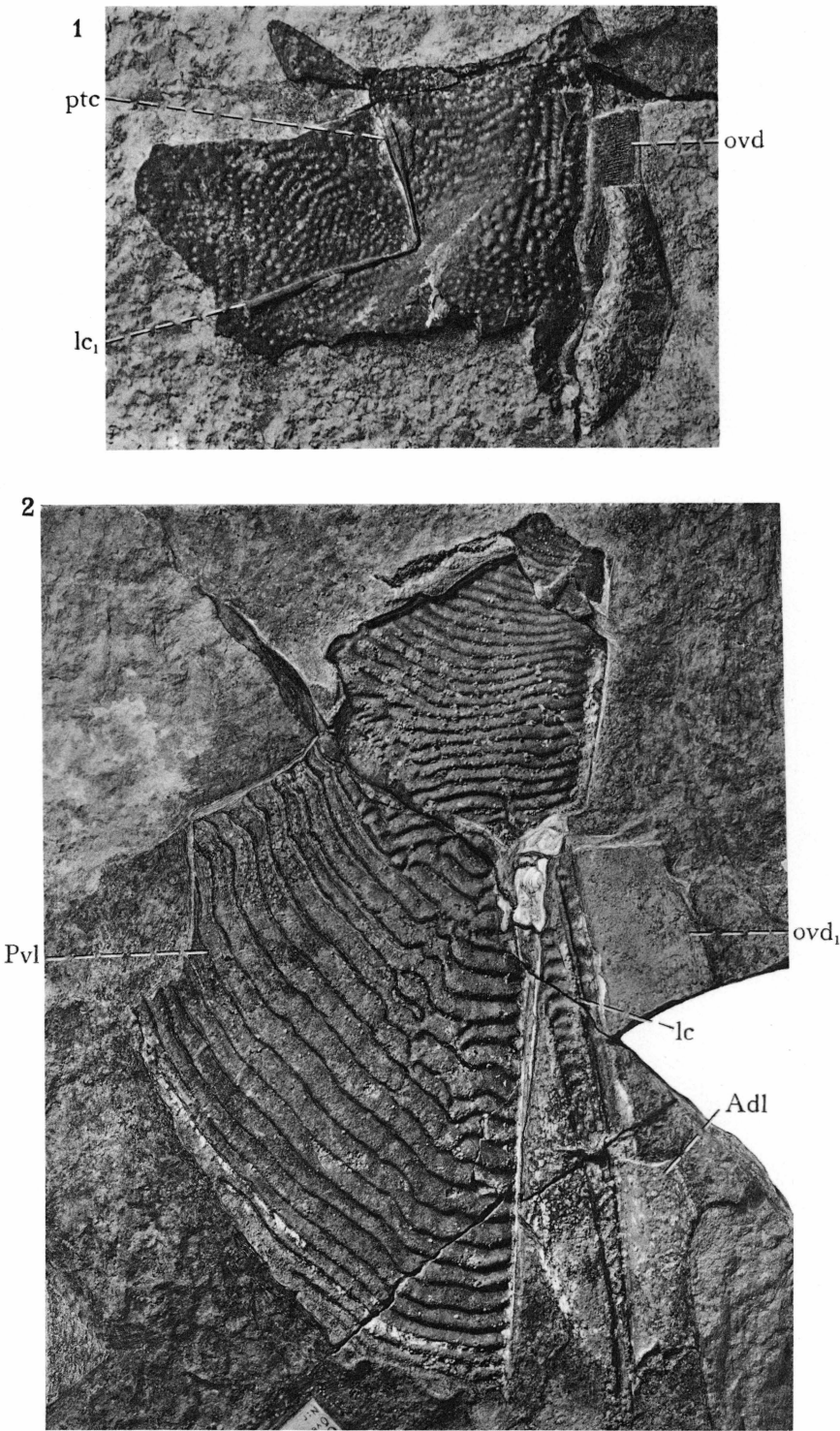


Plate 19.

Phyllolepis orvini HEINTZ.

A left anterior ventro-lateral plate. Impression of the internal (dorsal) side. Specimen no. 352a. Approximately $\frac{3}{4}$ of the nat. size.

a—b, antero-medial margin, which was in contact with the anterior median ventral plate; *ov*₁, area probably overlapping the anterior median ventral plate; *ov*₂, area overlapping the intero-lateral plate; *ov*₃, area overlapping the spinal plate; *ov*₄, area overlapping the posterior ventro-lateral plate.



Plate 20.

Phyllolepis orvini HEINTZ.

A right anterior ventro-lateral plate. Impression of the external (ventral) side. Specimen no. 346. Somewhat diminished. ($\frac{4}{5}$ of the nat. size).

a—b, antero-medial margin, which was in contact with the anterior median ventral plate.



Plate 21.

Phyllolepis orvini HEINTZ.

A right anterior ventro-lateral plate. Impression of the external (ventral) side.
Specimen no. 350. Approximately $\frac{3}{4}$ of the nat. size.



Plate 22.

Phyllolepis orvini HEINTZ.

A right anterior ventro-lateral plate preserved as impression of the external (ventral) side. Specimen no. 347. Approximately $\frac{3}{4}$ of the nat. size.



Plate 23.

Phyllolepis orvini HEINTZ.

Part of the ventral wall of the trunk armour with several of the plates almost in their natural position in relation to each other. Specimen no. 340. Approximately $\frac{1}{3}$ of the nat. size.

Avl, anterior ventro-lateral plate; *Il*, probably a part of the right intero-lateral; *Spi*, spinal plate; *Pvl*, posterior ventro-lateral plate.

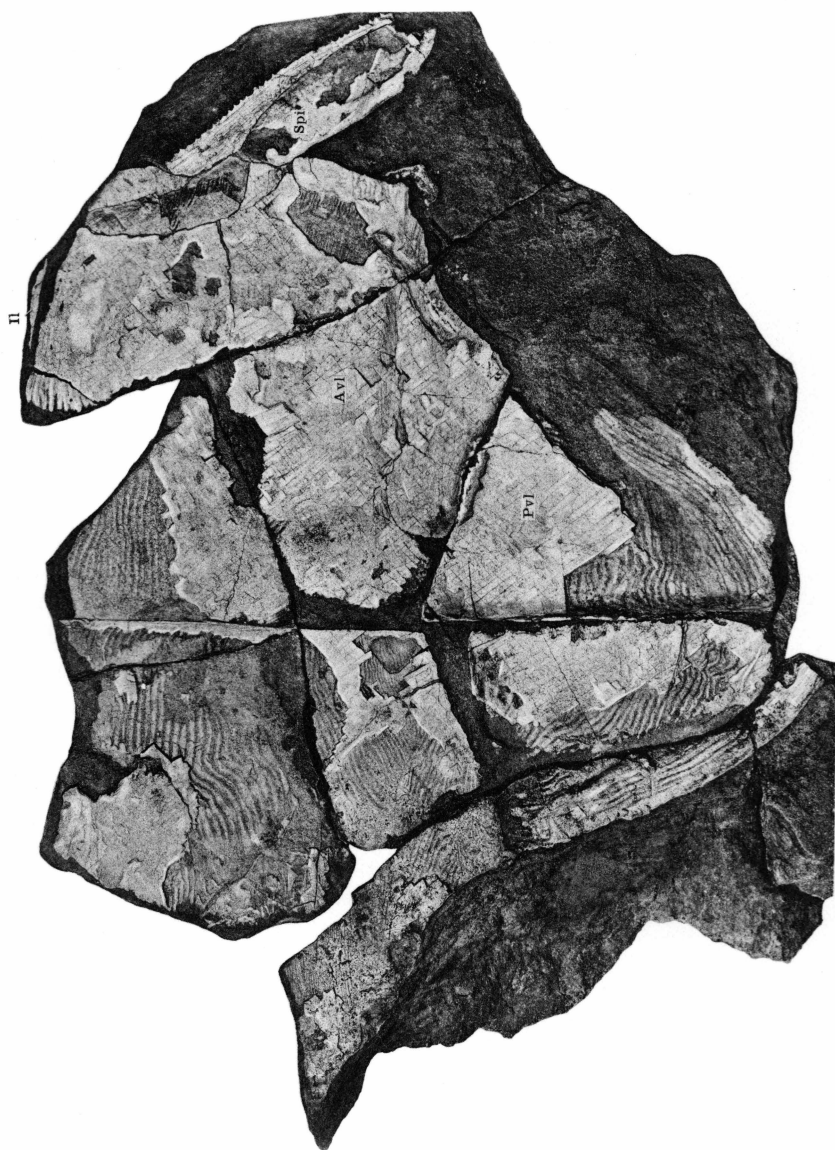


Plate 24.

A large piece of rock (approximately 1 m²) with five specimens of *Phyllolepis orvini* HEINTZ showing considerable parts of the armour in fairly good state of preservation. Specimens nos. 330a—f. Approximately $\frac{1}{4.5}$ of the nat. size.



Plate 25.

Phyllolepis orvini HEINTZ.

The most complete specimen on the piece of rock figured in pl. 24.

The specimen shows the dermal cranial roof, the dorsal and lateral walls and in addition also a part of the ventral wall (*Avl*) of the trunk armour. Specimen no. 330a. Approximately $\frac{3}{4}$ of the nat. size.

Al, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Cn*, median cephalic plate; *M*₁—*M*₅, marginals plates 1—5; *Md*, median dorsal plate; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *lc*, main lateral line of the trunk; *lc*₁, cephalic division of the main lateral line; *mp*, groove probably representing the middle pit-line of the Euarthrodiros; *poc*, preopercular sensory groove; *ptc*, postotic sensory groove; *soc*, supraorbital sensory groove.

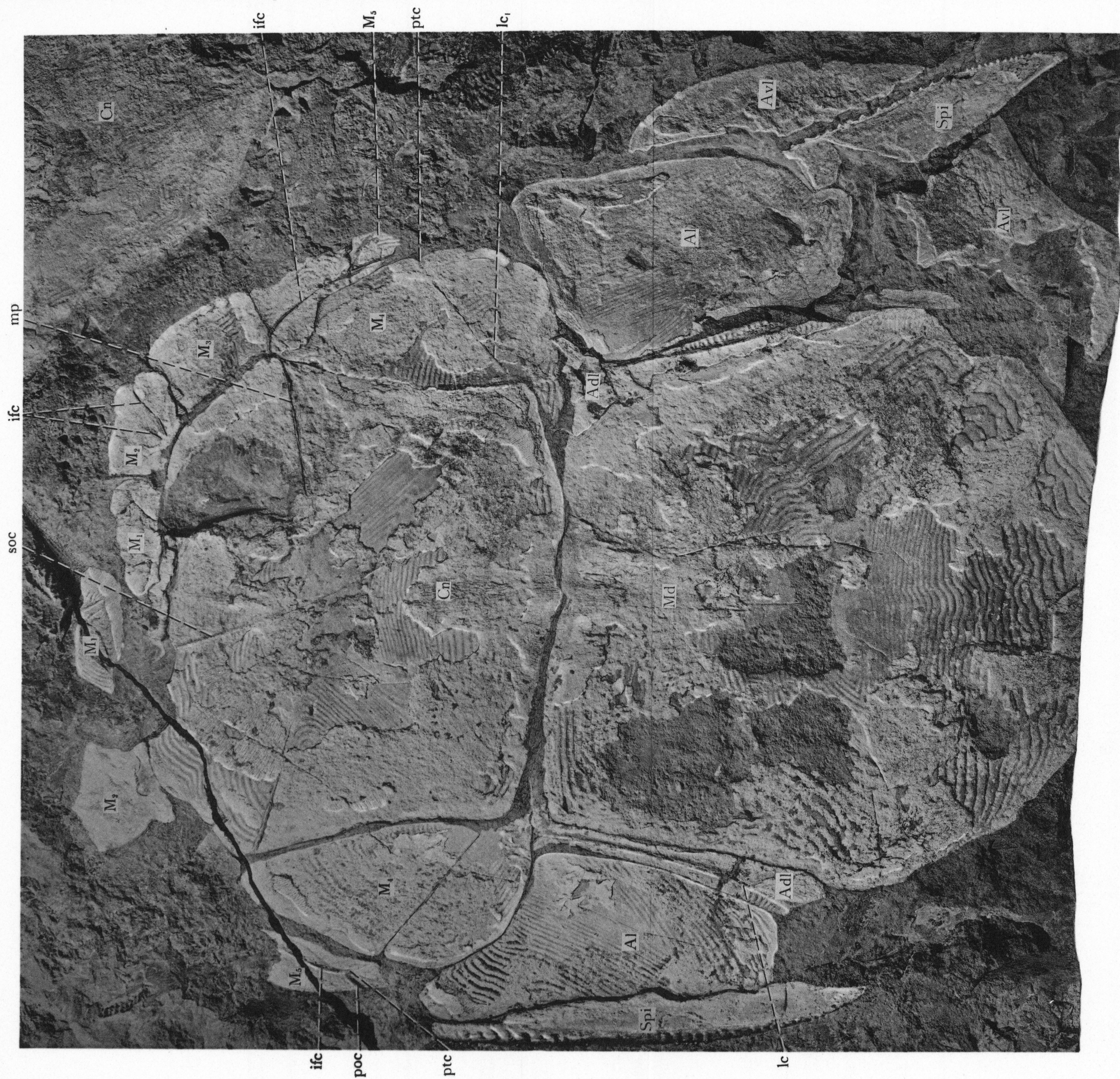


Plate 26.

Phyllolepis orvini HEINTZ.

Specimen showing a large part of armour. Specimen no. 330b. Approximately $\frac{3}{4}$ of the nat. size.

Al, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Cn*, median cephalic plate; *M*₄, marginal plate 4; *Md*, median dorsal plate; *Spi*, spinal plate; *lc*₁, cephalic of the main lateral line; *ptc*, postotic sensory groove.



Plate 27.

Phyllolepis orvini HEINTZ.

Several somewhat detached plates belonging to one individual. Specimen no. 330c. Approximately $\frac{3}{4}$ of the nat. size.

Al, anterior lateral plate; *Adl*, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Md*, median dorsal plate; *Pvl*, posterior ventro-lateral plate; *Spi*, spinal plate; *lc*, main lateral line of the trunk.

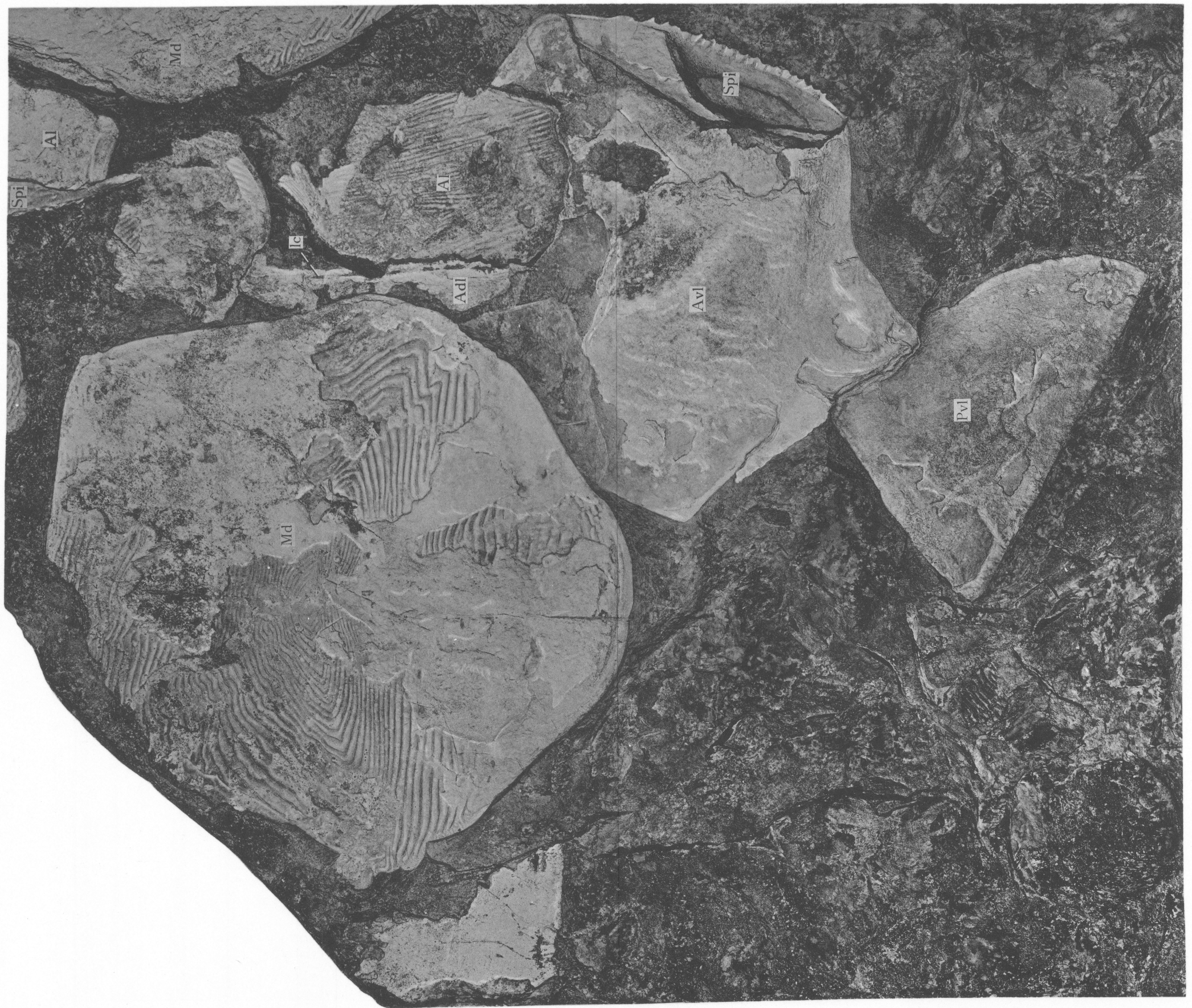


Plate 28.

Phyllolepis orvini HEINTZ.

Parts of the head and trunk armour of one individual. Specimen no. 330 d. Approximately $\frac{3}{4}$ of the nat. size.

Al, anterior lateral plate (anterior end only shown); *Cn*, median cephalic plate; *M*₂—*M*₅, marginal plates 2—5; *Md*, median dorsal plate; *Spi*, spinal plate; *ifc*, infraorbital sensory groove; *mp*, groove probably representing the middle pit-line; *lc*, cephalic division of the main lateral line; *poc*, preopercular sensory groove; *ptc*, postotic groove; *soc*, supraorbital sensory groove.

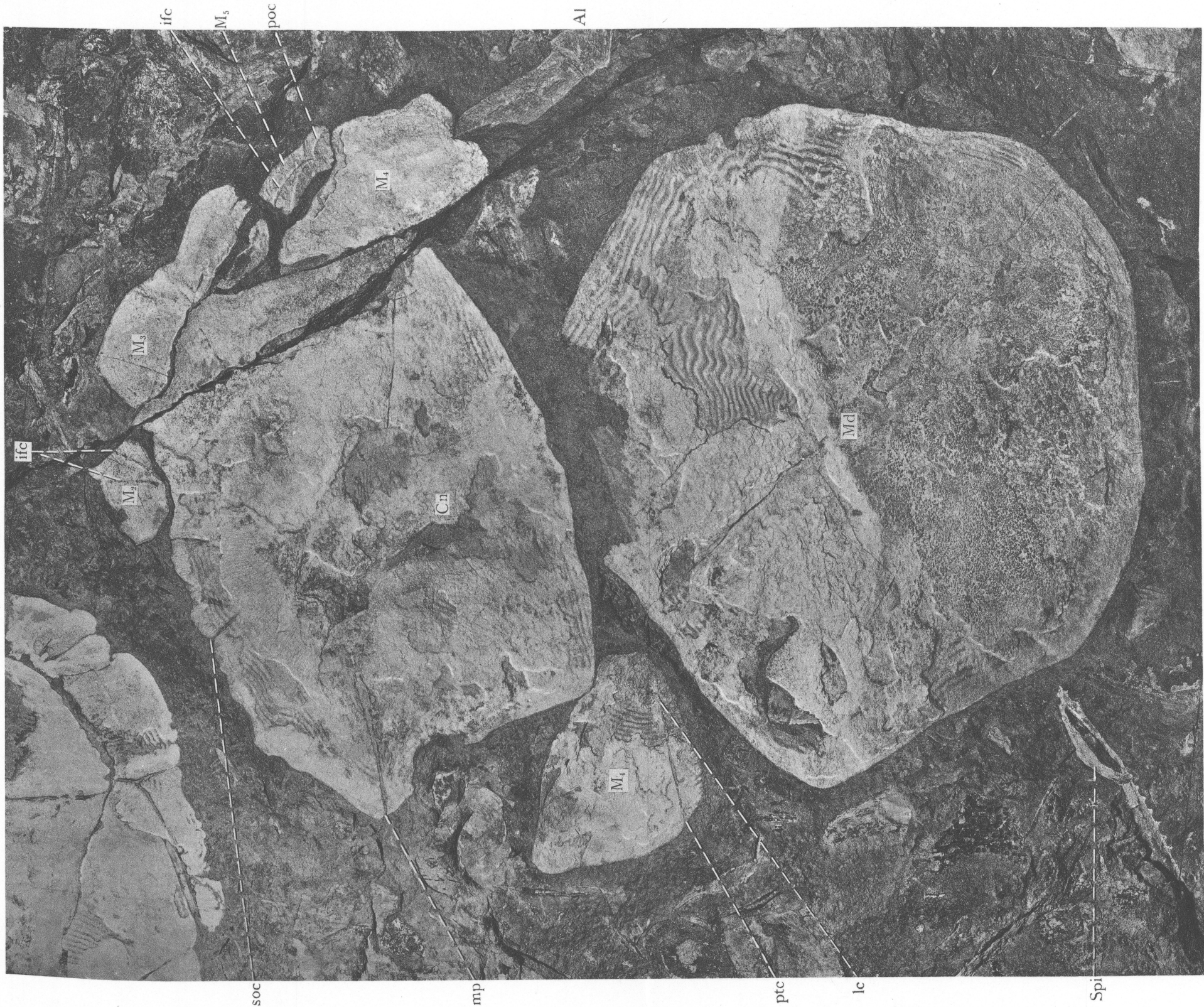


Plate 29.

Phyllolepis orvini HEINTZ.

Thin section through an external part of an anterior ventro-lateral plate showing the lamination of the superficial layer. The part of the section shown is situated between two adjacent ridges. The supposed canals of thread moulds well shown. Specimen no. 362c. Magnification approximately $150\times$.

cb, *cbr*, canals probably caused by thread moulds; *hav*, haversian canals; *sl*, superficial layer.

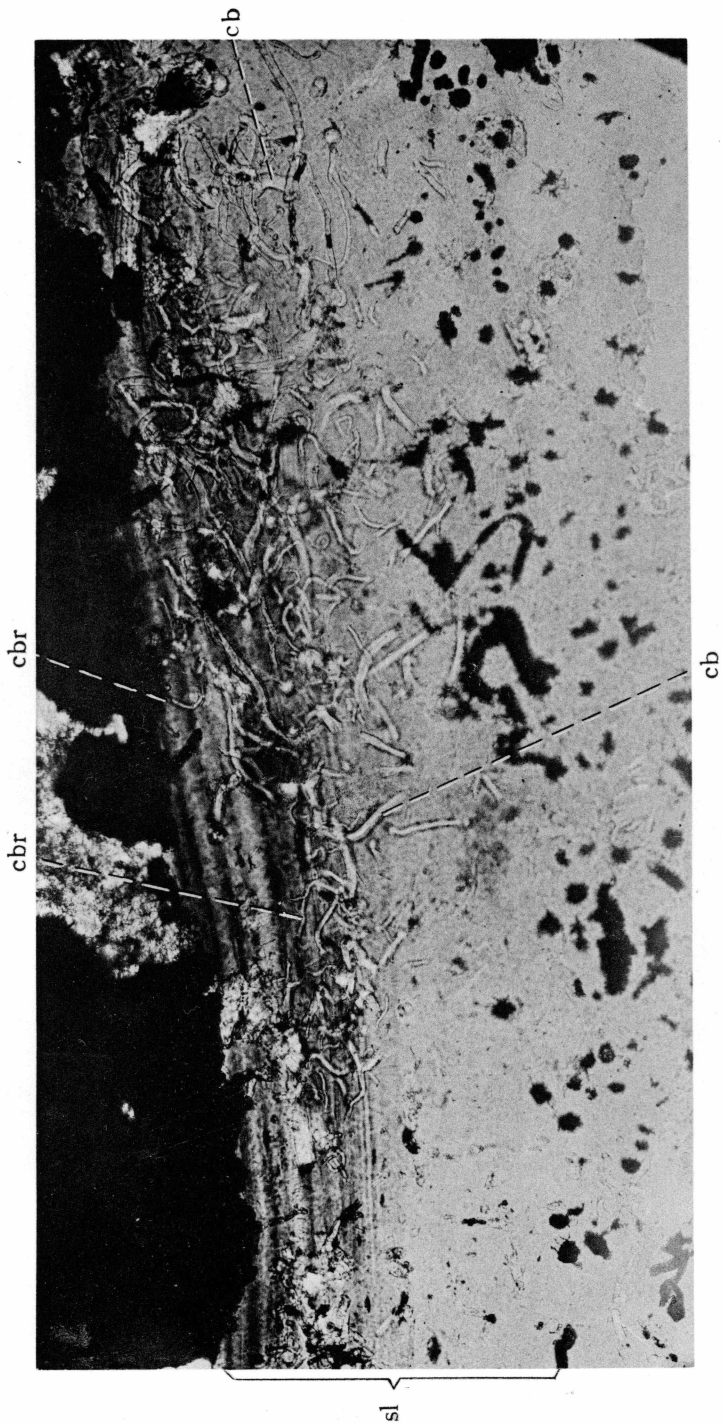


Plate 30.

Phyllolepis orvini HEINTZ.

Thin section through an external part of an anterior ventro-lateral plate showing well the canals which are supposed to have been caused by thread moulds. The section is taken through a ridge. Specimen 362 c. Magnification approximately $150\times$.

For explanations see pl. 29.

